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**EPIDEMIOLOGICAL STUDIES OF  
VACUUM EXTRACTION DELIVERY:  
INCIDENCE, RISK FACTORS AND  
SUBSEQUENT CHILDBEARING**

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# EPIDEMIOLOGICAL STUDIES OF VACUUM EXTRACTION DELIVERY: INCIDENCE, RISK FACTORS AND SUBSEQUENT CHILDBEARING

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“A woman in birth is at once her most powerful, and her most vulnerable. But any woman who has birthed unhindered understands that we are stronger than we know.”

— *Marci Macari*

To all childbearing women...

## ABSTRACT

The aim of this thesis was to bring focus on factors and outcomes associated with vacuum extraction delivery (VE). Delivery by VE is associated with both maternal risks (such as obstetric anal sphincter ruptures, postpartum hemorrhage and a negative birth experience) and infant risks (such as scalp lacerations, cephalohematoma, intracranial hemorrhage and brachial plexus injury). In Sweden, every seventh first time mother is delivered by VE, yet little is known about risk factors, incidence over time, birth experience and subsequent childbearing.

In study I we used the Medical Birth Register (MBR) to investigate factors related to VE and use over time among 589 108 primiparous women with singleton, term births in 1992-2010. We found that rates of VE increased from 11.5% in 1992 to 14.8% in 2010. The risk of VE increased with maternal age and gestational length, but decreased with increasing maternal height. Logistic regression analyses showed that the increased use of VE over time was partly explained by increasing maternal age and increased use of epidural anesthesia (EDA). Among women with and without EDA, the increase in VE over time was confined to VE due to the indication *non-reassuring fetal status*.

In study II we included a total of 265 456 singleton neonates born to nulliparous women at term between 1999 and 2008. Compared with women giving birth to a neonate with average size head circumference (35 cm), women giving birth to an infant with a very large head circumference (39–41 cm) had significantly higher odds of being diagnosed with prolonged labor (OR 1.49, 95% CI 1.33–1.67), signs of fetal distress (OR 1.73, 95% CI 1.49–2.03) and maternal distress (OR 2.40, 95% CI 1.96–2.95). The odds ratios for VE and cesarean section were thereby elevated to 3.47 (95% CI 3.10–3.88) and 1.22 (95% CI 1.04–1.42), respectively.

In study III, 3006 women were interviewed in their third trimester and one month after first childbirth to assess fear of birth and birth experience. Logistic regression was performed to examine the interactions and associations between fear of birth, mode of delivery and birth experience. Compared to women with low levels of fear of birth, women with higher levels of fear had a more negative birth experience and were more affected by an EmCS or VE. Compared to women with low levels of fears with a SVD, women with high levels of fear who were delivered by VE had a 10-fold increased risk of reporting a negative birth experience (OR 10.35, 95% CI 5.25-20.39). A SVD was associated with the most positive birth experience among the women in this study.

In study IV we used a cohort of 771 690 women who delivered their first singleton infant in Sweden between 1992 and 2010 to investigate the relationship between mode of first delivery and probability of subsequent childbearing. Using Cox's proportional-hazards regression models, risks of subsequent childbearing were compared across four modes of delivery. Compared with women who had a SVD, women who delivered by VE were less likely to have a second pregnancy (HR 0.96, 95% CI 0.95–0.97), and the probabilities of a second childbirth were substantially lower among women with a previous EmCS (HR 0.85, 95% CI 0.84–0.86) or an elective caesarean section (HR 0.82, 95% CI 0.80–0.83). There were no clinically important differences in the median time between first and second pregnancy by mode of first delivery.

## LIST OF SCIENTIFIC PAPERS

- I. Elvander C, Ekéus C, Gemzell-Danielsson K, Cnattingius S. Reason for the increasing use of VE in Sweden: a population-based study. *Acta Obstet Gynecol Scand* 2013; 92: 1175-1182
- II. Elvander C, Högberg U, Ekéus C. The influence of fetal head circumference on labor outcome: a population-based study. *Acta Obstet Gynecol Scand*. 2012 Apr;91(4):470-5
- III. Elvander C, Cnattingius S, Kjerulff K. Birth experience in women with low, intermediate or high levels of fear: Findings from the First Baby Study. *Birth* 2013 Dec;40(4):289-96
- IV. Elvander C, Dahlberg J, Andersson G, Cnattingius S. Mode of delivery and the probability of subsequent childbearing: a population based register study. *BJOG* 2014 Aug;19 doi: 10.1111/1471-0528.13021. [Epub ahead of print]

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## **LIST OF ABBREVIATIONS**

VE	Vacuum Extraction
CS	Cesarean Section
ElCS	Elective Cesarean Section
EmCS	Emergency Cesarean Section
SVD	Spontaneous Vaginal Delivery
CI	Confidence Interval
HR	Hazard Ratio
OR	Odds Ratio
BMI	Body Mass Index
ICD-9	International Classification of Diseases volume 9
ICD-10	International Classification of Diseases volume 10
IPI	Inter Pregnancy Interval
WHO	World Health Organization
ACOG	American College of Obstetricians and Gynecologists
RCOG	Royal College of Obstetrician and Gynecologists
EDA	Epidural Analgesia
OASIS	Obstetric Anal Sphincter Injuries
FHR	Fetal Heart Rate
CTG	Cardiotocography
MBR	Medical Birth Register
FBS	First Baby Study
BPD	Biparietal Diameter
FDA	Food and Drug Administration



# 1 INTRODUCTION

Being a nurse-midwife I feel concerned that fewer women give birth spontaneously today than two decades ago. What causes something as natural as labor to go wrong so often? What are we, as nurse-midwives and obstetricians doing when we intervene in labor and what are the consequences of our “good will” interventions? These important questions need to be answered if we want to provide best possible care to women in labor and optimize their birth experiences. The memory of giving birth follows women for the rest of their lives<sup>6-12</sup>.

Vacuum extraction (VE) is used in the second stage of labor when delivery needs to be expedited due to fetal or maternal indications. Compared with a spontaneous vaginal delivery (SVD), VE is associated with increased risks of maternal and neonatal complications<sup>13-16</sup>.

In Sweden, the rate of VE has increased over the past two decades along with increasing rates of cesarean sections (CS)<sup>17</sup>. Although VE or CS can be life-saving for the fetus, the mother, or both, the increase in VE and CS rates, without evidence of simultaneous decreases in maternal or neonatal morbidity, raises concern that instrumental deliveries are overused. In contrast to Sweden, the rate of VE has experienced a decline worldwide<sup>4, 18</sup>. However, research strongly supports the use of VE in the prevention of CS among first time mothers and states that deliveries by VE have a clear role in obstetrical praxis<sup>18-20</sup>.

One of seven first time mothers in Sweden give birth by VE. Yet, little attention has been directed towards VE deliveries. Little is known about the increase in rate, about maternal and neonatal risk factors for VE, and about the impact of VE on subsequent childbearing. Furthermore, women who give birth by VE more frequently report a negative birth experience<sup>21-24</sup>. However, few studies have focused on the associations between different levels of fear of birth, mode of delivery and birth experience.

It is important from a public health and clinical perspective to study the epidemiology of outcomes and factors associated with VE. In this thesis we have focused on risk factors, indications, and the use of VE in Sweden over time (Paper I), the importance of fetal head circumference for progress of labor and the risk of VE (Paper II), birth experience in relation to fear of birth and VE (Paper III), and subsequent childbearing after a primary delivery by VE (Paper IV).

## 2 BACKGROUND

Instrumental deliveries have been part of obstetrical practice for more than a century. Delivery by vacuum extraction (VE) started to gain widespread use in the 1950s when it was popularized in a series of studies by the Swedish obstetrician Dr. Tage Malmström<sup>25, 26</sup>. In the 1970s, it was more common than forceps in most northern European countries and today forceps deliveries only account for 0.1% of all vaginal instrumental deliveries in Sweden. The shift from forceps to VE is supported by clinical studies, showing advantages with VE, such as excessive force is not as likely with VE as the cup tends to detach, the extractor facilitates the rotation of the head for delivery, it is easily taught and it causes less maternal trauma<sup>19</sup>.

### 2.1 VACUUM EXTRACTION (VE) USE IN SWEDEN AND INTERNATIONALLY

In Sweden, since the beginning of the 1990s up until 2007 an increase in vacuum extraction (VE) use was noted. The rate then came down slightly and is currently around 8% in all women and 14-15% in first time mothers<sup>17</sup> (Fig.1). First time mothers represent approximately 80% of all VE for the reason that they are at higher risk than multiparous women to have their labor complicated by prolonged labor and fetal distress<sup>27</sup>.

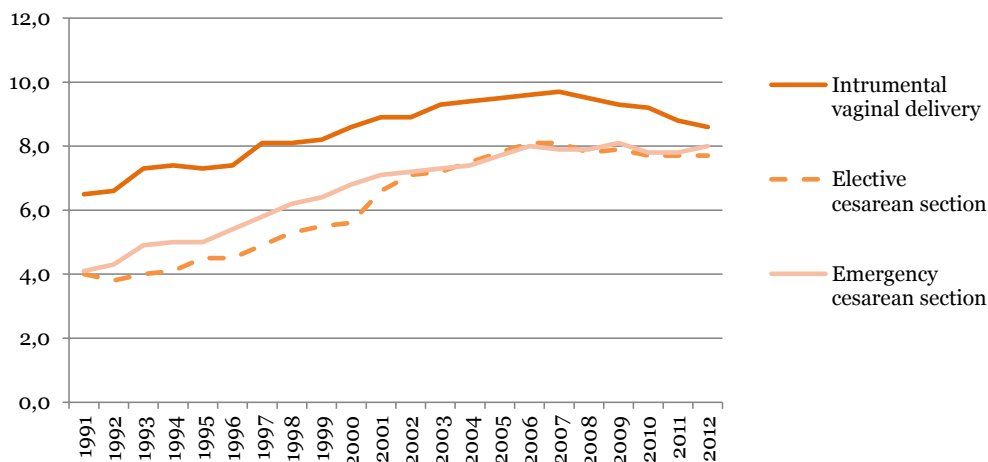


Fig 1. Birth statistics in percentage. Cesarean and instrumental deliveries among all women in Sweden 1991-2012<sup>17</sup>.

Since VE is sometimes an alternative to emergency cesarean section (EmCS), any discussion of either VE or cesarean delivery (CS) rates is incomplete without a simultaneous examination of data regarding the rate of the other procedure. As in many other countries<sup>28-32</sup> the rate of elective cesarean section (ElCS) and EmCS has increased in Sweden over the past decades (Fig.1), which has caused public health concerns and led to further research and recommendations for practice<sup>33, 34</sup>.

Sweden, Norway and Finland have been able to maintain an overall cesarean section rate below 20% (which is recommended by WHO<sup>4</sup>) whereas Spain, Australia, Canada Germany and USA report rates ranging from 26- 33%<sup>4, 35</sup>. In contrast, we have a fairly high rate of VE in Sweden while rates continue to decline in most countries with high cesarean section rates. In the United States, the VE rate is below 3%<sup>36</sup>, while the CS rate is 32%<sup>35</sup>.

In 1985, the World Health Organization (WHO) issued a consensus statement suggesting there were no additional health benefits associated with a cesarean section rate above 10–15%<sup>2</sup>. In 2010 another report by WHO stated that cesarean section rates below 20% is considered acceptable due to demographic changes such as older women having children and higher prevalence of obesity<sup>4</sup>.

There are no official recommendations on VE rates, but it has been stated that VE has a clear role in obstetrical praxis, obstetrician's should have adequate training and it should be the primary mode of delivery when an expedited delivery is indicated and selection criteria are met (i.e. fully dilated cervix, fetal membranes are broken, fetal head at or below the ischial spines, and gestational age >34 weeks)<sup>19, 20, 37</sup>.

## 2.2 FACTORS ASSOCIATED WITH INCREASED RISK OF VE

Indications for a delivery by VE are non-reassuring fetal status, prolonged labor, maternal distress, correction of position and if there is a contraindication for maternal pushing<sup>38, 39</sup>. The two most common indications are *prolonged labor* and *non-reassuring fetal status*<sup>40</sup>, and these indications account for a majority of all VE deliveries<sup>41, 42</sup>. Prolonged labor and a non-reassuring fetal status indicate that the extraction is performed for maternal and fetal reasons, respectively.

In Sweden, EmCS is the first choice of method of delivery during the first stage and VE is the first choice of method of delivery during the second stage. However, in many parts of the U.S and other western countries, the use of VE has declined dramatically and EmCS is the first choice of method of delivery also in the second stage<sup>18, 43</sup>.

## *Prolonged labor*

Prolonged labor occurs due to dystocia, which refers to inadequate progress of labor. It is caused by a combination of factors that traditionally have been understood to either involve the expulsive forces (uterine contraction or powers), or presentation, position, and fetal development (passenger) or the maternal bony pelvis (passage) or a combination of these. This suggests two types of dystocia: a mechanical obstruction (mechanical dystocia) and one that is related to contractions (functional dystocia). The presence of strong uterine contractions but lack of cervical dilation and fetal descent is a defining characteristic of obstructed dystocia distinguishing it from functional dystocia. In high income countries functional dystocia is most common.<sup>44</sup>

Dystocia can occur in the first or second stage of labor and the overall incidence has been reported to be between 21 and 37% among nulliparous women and between 2 and 8% among parous women<sup>45-47</sup>.

There is no clear consensus on the length of normal labor or for diagnostic criteria if dystocia. It is most common to use the term when augmentation is needed regardless of subsequent mode of delivery<sup>48</sup>.

*IN THIS THESIS THE TERM PROLONGED LABOR INCLUDES THE FOLLOWING DIAGNOSES:*

- Primary inadequate contractions
- Secondary uterine inertia
- Prolonged labor first stage of labor
- Prolonged labor second stage of labor
- Other unspecified uterine inertia

Criteria for dystocia in the first stage of labor are commonly set to cervix dilating less than 0,5-1cm/hour during 2-4 hours. In Sweden, national guidelines recommend augmentation for prolonged labor when expected normal progress during the first stage of labor (on average 1cm/hour) has been delayed by 3 hours. Or, when expected normal progress during the second stage has discontinued, either during the descending phase for at least 1 hour or during the expulsive phase with active pushing for at least 30 minutes<sup>49</sup>.

A diagnosis of dystocia requiring augmentation is not equal to instrumental delivery. Many women with the diagnosis have a SVD. Dystocia during the second stage of labor is an indication for VE and usually refers to lack of continuing progress for 3 hours among nulliparous women with EDA, or 2 hours without EDA. In multiparous women it refers to lack of continuing progress for 2 hours with EDA, or 1 hour without EDA<sup>37, 39, 48</sup>. In this thesis, women delivered by VE who also were diagnosed with any kind of dystocia/prolonged labor were assumed to be delivered by VE due to this complication. Women who were diagnosed with both non-reassuring fetal status and prolonged labor were handled separately depending on the analysis.

There are several factors known to contribute to prolonged labor and dystocia; maternal age<sup>40, 50, 51 50, 52</sup>, height<sup>53, 54, 47</sup>, obesity<sup>55, 56</sup>, nulliparity<sup>27</sup>, gestational diabetes, length of gestation and high birth weight<sup>46, 57</sup>. However, little research has focused on associations between these variables and dystocia during the second phase of labor, and thereby the risk of VE.

In study I and II we choose to study these factors and their association with VE but we also included new potential risk factors such as head circumference, sex, pre-eclampsia, country of origin, and whether the woman was living with her partner.

### *Non-reassuring fetal status*

A more appropriate term for the indication *signs of fetal distress* (which is used synonymously with *fetal distress* in paper I and II) is *non-reassuring fetal status*. Fetal distress implies an ill fetus, while non-reassuring fetal status describes the clinician's interpretation of data regarding fetal status. Due to recommendations this term will be used throughout this thesis<sup>58</sup>.

Signs of a non-reassuring fetal status include fetal heart rate anomalies, meconium in amniotic fluid, biochemical evidence of fetal distress or other evidence<sup>17</sup>.

Maternal age, height, BMI, nulliparity, gestational diabetes and high birth weight have all been associated with the risk of fetal

distress during labor<sup>59</sup> but there is limited research on these factors' association with non-reassuring fetal status specifically in the second stage of labor and thereby an indication for VE.

#### NON-REASSURING FETAL STATUS

- Fetal heart rate anomalies
- Meconium in amniotic fluid
- Biochemical evidence of fetal distress
- Other evidence

The term *non-reassuring fetal status* has a low positive predictive value even in high-risk populations and is often associated with an infant who is in good condition at birth as determined by the Apgar score or umbilical cord blood gas analysis or both. It is therefore important to clarify that non-reassuring fetal status is not equivalent to birth asphyxia. One way to identify infants with birth asphyxia (including mild asphyxia) has been to look at Apgar <7 at 5 minutes. Among term live born infants the rate of Apgar <7 at 5 minutes is less than 1%. Apgar <7 at 5 minutes occurs in 2.5% out of all neonates delivered by VE in Sweden, which equals to approximately 200 neonates/year. However, only 3% of all neonates delivered by VE due to non-reassuring fetal status presented with Apgar <7 at 5 minutes<sup>41</sup>.

Epidural analgesia in labor is a highly effective method of labor pain relief, but there is controversy of its influence on the progress of labor. According to a Cochrane review, the use of an EDA was found to increase the risks of oxytocin administration, longer second stage of labor, operative vaginal delivery (VE), and EmCS for fetal distress<sup>60</sup>. However, a causal link between EDA and CS due to prolonged labor could not be established. Other more recent studies, report that the association between EDA and CS due to prolonged labor is likely to be causal<sup>41, 61</sup>. It can seem like a plausible finding as EDA increases the need for augmentation which indicates that there is a complication of prolonged labor, a common indication for EmCS. These studies are however observational and there is a risk of confounding even after adjusting for covariates.

### **2.3 GUIDELINES ON THE USE OF VE**

A VE delivery should only be performed if there is an appropriate indication and patient criteria are met. The procedure should be executed according to guidelines. In 2000, the American College of Obstetricians and Gynecologists (ACOG) published guidelines<sup>38</sup> on the use of operative vaginal delivery (both forceps and VE, which included a list of accepted indications and prerequisites. In 2010, the Swedish Society for Obstetricians and Gynecologists published very similar national recommendations<sup>39</sup> which are described below.

- *Indications* for a delivery by VE are non-reassuring fetal status, prolonged labor, maternal distress, correction of position and if there is a contraindication for maternal pushing, for example cardiac disease or hypertensive crisis. When a VE is performed in Sweden the practitioner is obliged to report the indication. It is preferred that they use one (1) indication, but sometimes two (2) or more indications are used.
- *Contraindications*: Fetal malpresentation (eg, breech, transverse lie, brow, face), gestational length < 34+0 weeks, known or suspected fetal bleeding disorder, incomplete dilatation of the cervix, intact fetal membranes, unengaged vertex, fetal malpresentation, and suspected cephalopelvic disproportion
- *Discontinue extraction* if two pop-offs have occurred, if the fetal head is not descending after three pulls/three contractions, if the fetal head is not engaged to the pelvic floor after three pulls/three contractions or if the woman is not expected to deliver within 15 minutes or at the most 20 minutes after the attachment of the cup.

## 2.4 OUTCOMES OF VE

### *Neonatal outcomes*

A VE is considered a safe procedure with low incidence of severe complications for the neonate if performed correctly<sup>19</sup>. However the arguments against the use of VE, which cause great variation in rates between countries, regions and individual practitioners, are linked to the potential trauma suffered by the newborn or the mother. Compared with spontaneous vaginally delivered neonates, those delivered by VE suffer an increased risk of complications. Some complications are milder, such as scalp edema<sup>16</sup> retinal hemorrhage or cephalohematoma<sup>62</sup>, while other complications, such as brachial plexus injury<sup>63</sup>, subgaleal hematoma<sup>13, 64-66</sup>, skull fractures or intracranial hemorrhage<sup>13, 16, 66</sup> are more severe and can potentially affect the neonatal long term health.

Even though the risk of complications is low, VE is not routinely used in some countries, and EmCS are performed instead<sup>67</sup>. In 1994-1998, the US Food and Drug Administration (FDA) received reports on 12 deaths during the previous four years that occurred due to VE delivery. Due to these reports FDA issued a warning about the potential dangers of VE delivery<sup>68</sup>. A couple of years later, American College of Obstetricians and Gynecologist (ACOG) gave out a practice bulletin on operative vaginal delivery<sup>38</sup>, in which they emphasized the risks if the procedure was not correctly performed. Referring to two studies<sup>65, 69</sup>, they reported that the risk of subgaleal hemorrhage was 26-45/1000 VE births. In a recent Swedish study the rate of all neonatal intracranial hemorrhages (both traumatic and non-traumatic intracranial hemorrhages) was 19/10 000 VE births<sup>13</sup>. The technique is important when performing VEs. More infrequent use of the procedure leads to inadequate training, which is a large problem in many settings. An incorrectly performed extraction contains much higher risks. In settings where VE is routinely used, it is a low risk procedure for the neonate.

### *Maternal outcomes*

VE has shown to cause less maternal trauma than forceps delivery<sup>19</sup>, but SVD is the mode of delivery which involves the lowest complications rates. One of the most frequently reported complications for women who deliver by VE is obstetric anal sphincter injuries (OASIS), also called a grade III or grade IV tear<sup>19, 70</sup>. OASIS occurs in 13-14% of all VEs<sup>14, 71</sup> and is related to short- and long term maternal complications, such as anal incontinence<sup>15, 72</sup>, sexual dysfunction<sup>73</sup>, urinary incontinence<sup>15, 74</sup>, pain<sup>75</sup> and a reduced quality of life <sup>76-78</sup>. The frequency of fecal incontinence in

#### LEVELS OF TEARING:

**Grade I** superficial tear of the vaginal mucosa and perineum

**Grade II** deep perineal tear not affecting the anal sphincter

**Grade III** partial or total tear through the anal sphincter

**Grade IV** grade III with extension through the rectal mucosa

women with OASIS 6 months after delivery has been reported to be around 17%. However, a larger number of women have other less severe incontinence problems lasting much longer<sup>15, 78</sup>.

Episiotomy is more frequently used among women who deliver by VE<sup>71</sup> and refers to a surgical incision in the perineum designed to enlarge the vagina and assist in childbirth. It can be performed by the physician in order to facilitate a fast delivery or to prevent OASIS. Several recent studies support liberal use of lateral episiotomy at VE for nulliparous women at high risk of OASIS<sup>14, 59, 60</sup>.

Increased risk of bleeding and a negative birth experience are other complications of VE; the latter will be described separately in the section below. The risk of increased bleeding is associated with higher prevalence of tearing but also due to higher incidence of atoni which is more common in women with a long duration of the second stage of labor which is an indication for VE<sup>79</sup>.

## **2.5 FEAR OF BIRTH AND BIRTH EXPERIENCE**

### *Fear of birth*

Fear of childbirth is a common phenomenon in pregnant women. From a psychometrical point-of-view fear of childbirth can be seen as a continuum, from almost no fear to extreme fear to give birth. In the latter case, the fear can have a disabling effect that interferes with occupational or academic functioning, with domestic and social activities, or with relationships<sup>80</sup>. The prevalence of fear of birth is reported to be around 20% and 6-10% of all women experience intense fear<sup>81-95</sup>. The prevalence varies in different study populations, and is influenced by cultural perspectives<sup>83, 84</sup>, demographic factors such as age<sup>91, 96, 97</sup>, education<sup>94, 96, 97</sup> and employment<sup>98-100</sup>. Most studies have found women expecting their first baby to be more fearful than multiparous women but the reverse has also been demonstrated<sup>81, 84, 86</sup>. Fear of birth can be used as a medical diagnosis and indication for ELCS<sup>101-103</sup>. The existing literature on associations between fear of birth and the risk of EmCS reach different conclusions<sup>81, 83, 99, 104</sup>. However, it has previously been reported that women with high levels of fear use EDA to a larger extent and also are more prone to report a negative birth experience<sup>101, 105-107</sup>.

### *Birth experience*

Birth experience is closely related to fear of birth. It is a multidimensional concept and is affected by personal control, perceptions of support, care from relatives and midwives, sense of security, involvement in decision-making, self-efficacy and expectations<sup>108, 109</sup>. Endurable labor pain and access to analgesia during childbirth



are also important factors. However, effective pain relief is not always related to satisfaction, nor is a high level of pain always related to dissatisfaction. Women with fear of birth have more often a negative birth experience and a negative birth experience can lead to fear of birth. Several studies report that women who give birth by VE or EmCS have more often a negative birth experience than women with a SVD with no major complications<sup>22, 24, 110-115</sup>. A negative birth experience may have lifelong implications<sup>116</sup>, and a difficult first birth may color the memory of the birth experience for the rest of the woman's life<sup>117</sup>. A negative birth experience has been associated with subsequent infertility<sup>11</sup> interpreted as avoiding or postponing further childbearing<sup>118</sup>.

### 3 AIMS

The aim of paper I was to investigate possible risk factors for VE and EmCS in primiparous women with singleton term pregnancies. We also investigated whether time differences in risk factors explain the increasing VE rate over time.

The aim of paper II was to investigate the association between postnatal head circumference and the prevalence of three main indications for instrumental and operative delivery, namely *prolonged labor*, *non-reassuring fetal status* and *maternal distress*. The second aim was to investigate the association between postnatal head circumference and risks of VE and EmCS.

The aim of paper III was to study associations between level of fear of birth, mode of delivery, and birth experience.

The aims of paper IV were to investigate 1) if the probability of having a subsequent birth differ between women with a primary VE, EmCS or ElCS, and women with a primary SVD; 2) if the interpregnancy interval between the first and the second pregnancy differs by mode of first delivery; and 3) if mode of first and second delivery is associated with the probability of having a third child.

## 4 SUBJECTS AND METHODS

### *Medical Birth Registry (MBR)*

Study I, II and IV were all conducted in Sweden, a country well suited for epidemiological research<sup>119</sup>. The public health care system with transparent referral systems, virtually no private institutional care and a generally high public acceptance to registries and research have contributed to excellent population-based data sources, the MBR being one of them. In Sweden, labor and delivery care is more similar across the country than in many other countries, and all hospitals tend to follow national recommendations of praxis<sup>17</sup>. The care is not biased by level of insurance or individual practitioner's interests, which can introduce bias in epidemiological research.

The MBR is kept by the Swedish National Board of Health and Welfare. The registry includes all live births from 22+0 gestational weeks and stillbirths. Inclusion criteria for stillbirths was recently changed from 28+0 gestational weeks (1973-2008) to 22+0 gestational weeks (complete from 2009 and onwards). The collection of data for the MBR starts on the woman's first antenatal visit. The nurse-midwife records the woman's history according to a standard protocol, including smoking habits, infertility problems, height, weight, reproductive and obstetric history, medications etc. Information is prospectively collected during pregnancy, delivery, and the neonatal period, until the mother and infant are discharged from hospital. Obstetrical information and information on the infant such as mode of delivery, use of EDA, complications during delivery, single or multiple birth, birth weight, gestational age, Apgar score, sex, head circumference, fetal presentation, and infant diagnoses is recorded by nurse-midwife or obstetrician in the medical records before discharge from hospital.

The MBR has been evaluated three times. The first two evaluations are summarized in Cnattingius S, Ericson A, Gunnarskog J, Källén B. A quality study of a Medical Birth Registry. *Scand J Soc Med* 1990;18:143-148<sup>120</sup>. The results of the third evaluation are available in Swedish on the website of the National Board of

"The Swedish Medical Birth Register was established in 1973 by an act of the Swedish parliament. The purpose of the register is to compile information on ante- and perinatal factors, and their importance for the health of the infant. Even though the basic structure of the registry has remained unchanged during the years since 1973, there have been major modifications to content and methods of data collection<sup>3</sup>."

Health and Welfare<sup>3</sup>. As with all large registries, there are errors in the data recorded and some data missing from the register. A relatively small proportion of births are not registered, but only 1-2% for most years which is acceptable. The quality of variables can vary as some variables have greater data loss than others, e.g. infant diagnoses and smoking in late pregnancy. Some of the key variables in papers I, II and IV were birth weight, head circumference, length of gestation and mode of

delivery. Information on these variables is of good quality and hierarchical systems are used to find the most accurate information from the medical records.

### *The First Baby Study (FBS)*

Study III was based on data from the First Baby Study (FBS), which is a five year study, funded by the National Institutes of Health (NIH). Funding began May 1, 2008 and the purpose of this study was to investigate the effect of mode of first delivery on subsequent childbearing.

The cohort includes 3 006 English and Spanish speaking nulliparous women aged 18–35 years in Pennsylvania, enrolled in their third semester. Women who were planning to deliver at home or in a birthing center not associated with a hospital were not included. However, women under the care of a midwife were included in the study. Participants were recruited from a variety of settings, including childbirth education classes, hospital tours, health fairs, targeted mailings to potentially eligible women throughout the state of Pennsylvania, newspaper advertisements, and recruitment materials posted in low income clinics and ultrasound centers throughout the state. Recruitment of study participants began in January 2009 and was completed in April 2011. The baseline telephone interviews occurred prior to the beginning of labor, at 30 to 42 weeks of gestation (median gestational age at interview was 35 weeks). The baseline interview assessed reproductive and health history; pregnancy complications and health care utilisation; mode of delivery preference; relationship factors; psychosocial factors; future birth desires and intentions; and sociodemographic factors. The 1-month postpartum telephone interview focused on the delivery experience and assessed factors related to labor and delivery; postpartum feelings about childbirth; in-hospital and postdischarge complications; and the health of the baby and the mother. The subsequent interviews (at 6, 12, 18, 24, 30, and 36 months postpartum) measure sexual relations and use of birth control; subsequent pregnancies; relationship factors; future birth desires and intentions; the health of the mother, the index child and all subsequent children; and sociodemographic factors.

There were 74 women who completed the baseline interview but did not complete the 1-month interview, some because of fetal demise, but most because they decided not to participate. Those who did not complete the 1-month interview were replaced until the targeted enrollment number of 3000 women was reached. It was a slight over-enrollment and the final sample size was 3006 study participants. Therefore, a total of 3080 women were recruited, consented and completed the baseline interview, and 3006 completed both the baseline and 1-month postpartum interviews. The 74 women who dropped out of the study after the first interview were different from those who completed the 1-month interview: they were younger, less likely to be covered by private insurance and more likely to live in an urban area. They were not significantly different in race/ethnicity. Birth certificate and hospital discharge data was obtained for the 3006 study participants, with a match rate of 99.4% for the birth certificate data, 99.5% for the mothers' hospital discharge data

and 98.4% for the babies' hospital discharge data. The study design and recruitment process is published in detail in Kjerulff KH et al<sup>121</sup>.

#### **4.1 PAPER I**

Based on data from the Swedish Medical Birth Register, we studied births in Sweden 1992-2010. We excluded births to parous women, stillbirths, forceps deliveries, multiple births, deliveries with gestational age <37 or ≥42 completed weeks, or no documented gestational length, ELCS, childbirths in non-cephalic presentations and those with no documented presentation. In total we included information on 589 108 births.

In this study we:

- estimated risk factors for VE and emergency cesarean section. We decided which variables to study based on biologic reasoning and plausibility<sup>122</sup>;
- investigated the different levels of impact of the risk factors on the two main indications for VE, *non-reassuring fetal status* and *prolonged labor*;
- performed logistic regression analyses to evaluate if demographic changes of the risk factors could be related to the increase in VE use over time;
- stratified for the use of EDA, which has shown to be associated with the risk of VE, and the influence of EDA on the progress of labor is very complex<sup>60</sup>;
- investigated interactions between use of EDA (yes/no) and year of birth (continuous) and risk of VE;
- mainly used logistic regression analysis for statistical analyses.

#### **4.2 PAPER II**

As with paper I, this study was based on data from the Swedish Medical Birth Register. The study population included all singleton neonates both to nulliparous women at term (≥37 to <42 weeks) in cephalic presentation between 1999 and 2008. After exclusion of infants with missing or implausible data on head circumference or birth weight, the final sample included 265 456 births.

In this study we:

- calculated the proportion of the outcomes prolonged labor, non-reassuring fetal status, maternal distress, VE, and EmCS in relation to fetal head circumference;
- created logistic regression models to study the association between head circumference and prolonged labor, non-reassuring fetal status and maternal distress. We adjusted for potential confounders such as time, birth weight, maternal height, BMI, age and EDA;

- calculated attributable risk proportions for a large head (37–41cm) versus a normal size head (35cm) on the risk for VE and emergency cesarian section.

### 4.3 PAPER III

This study was based on data from the First Baby Study (FBS), Pennsylvania, USA. The cohort includes 3 006 English and Spanish speaking, nulliparous women aged 18–35 in Pennsylvania who were enrolled in their third semester. The baseline interview assessed reproductive and health history, pregnancy complications, psychosocial factors, fear of birth and sociodemographic factors. The 1-month postpartum telephone interview focused on the delivery experience and assessed factors related to labor and delivery; postpartum feelings about childbirth; in-hospital and postdischarge complications; and the health of the baby and the mother.

In this study we:

- measured associations between maternal characteristics and fear of childbirth in three categories (low, intermediate and high) by using chi-square tests;
- let the quintile of women with the lowest scores on the FBS Birth Experience Scale represent those having a negative birth experience;
- investigated associations between level of fear of birth and mode of delivery and risk of negative birth experience by using logistic regression analyses.

#### *The FBS Birth Anticipation Scale*

The FBS Birth Anticipation Scale was developed as follows: as part of a qualitative interview study of 10 women in their third trimester, the participants were asked to report how they felt about their upcoming delivery. Based on the answers, a list was developed of the adjectives the women used including “*nervous*”, “*happy*”, “*excited*”, “*worried*”, “*fearful*”, “*relaxed*”, “*terrified*”, “*delighted*” and “*calm*”. Several experts in women’s health were asked to review this list of adjectives and to suggest additional adjectives to include. This content analysis yielded the addition of the adjective “*sad*”. Using the response options of “*extremely*”, “*quite a bit*”, “*moderately*”, “*a little bit*” and “*not at all*”, the instrument was pilot-tested in an additional sample of pregnant, nulliparous women attending a childbirth education class (n = 16). Pilot-test respondents completed this scale quickly and easily and reported no confusing or problematic items. Below is a figure of the instrument and what it looked like when it later was used in the FBS telephone interviews.

B6. I am going to read a list of words and I would like you to tell me how you feel about your upcoming delivery, using: Extremely, Quite a bit, Moderately, A little, and Not at all.								
"To what extent do you feel _____ about your upcoming delivery ?"								
		Extremely	Quite a bit	Moderately	A little bit	Not at all	Don't know	Ref
A	Nervous	1	2	3	4	5	8	9
B	Happy	1	2	3	4	5	8	9
C	Worried	1	2	3	4	5	8	9
D	Excited	1	2	3	4	5	8	9
E	Fearful	1	2	3	4	5	8	9
F	Relaxed	1	2	3	4	5	8	9
G	Terrified	1	2	3	4	5	8	9
H	Sad	1	2	3	4	5	8	9
I	Delighted	1	2	3	4	5	8	9
J	Calm	1	2	3	4	5	8	9

Table 1. The FBS Anticipation Scale as it looked during the telephone interviews. It was later revised after factor analysis.

Exploratory factor analysis of the FBS-Birth anticipation scale was then conducted using principal components extraction with varimax rotation. The items *happy*, *excited*, *sad* and *delighted* were extracted and the final FBS Birth Anticipation Scale included 6 items: *nervous*, *worried*, *fearful*, *relaxed*, *terrified* and *calm*.

For PAPER III, a total score was created by summing participant responses to the items; the higher the score the more fearful the woman was about the upcoming delivery (the score of item *calm* was reversed). Total score could range from 6 (no fear) to 30 (extreme fear) and the overall Cronbach's Alpha for this scale was 0.82. We categorized the total scores into quintiles as follows: 6–13, 14–15, 16–17, 18–20, and 21–30. We then categorized the scores into three categories: 6–13 (the lowest quintile), 14–20 (the three middle quintiles), and 21–30 (the highest quintile). These categories were labeled "low fear," "intermediate fear," and "high fear." Previous research has shown that it is fair to believe that about 20 percent of all women who are pregnant have a fear of birth <sup>22, 123-126</sup>. By letting only the top quintile represent the women with a real fear of birth, we hoped to avoid the inclusion of women in this group who scored high on the scale but did not actually have a fear of birth. There existed no information whether or not women received counseling for their potential fear sought support or advice, or explored other methods to cope with anxiety or fear related to their upcoming birth.

Scores on the FBS Birth Anticipation Scale ranged from a low of 6 (the minimum possible score) to a high 29 of 30 (the maximum possible score). The mean score was 16.9 (SD = 4.6) and the median score was 17.

### *The FBS Birth Experience Scale*

The FBS Birth Experience Scale was developed based on 16 items in the 1-month postpartum interview. The participants were asked to think back to right after they had their baby and report the extent to which they felt *exhausted, on cloud nine, disappointed, in pain, sick, delighted, upset, excited, worried, calm, like a failure, thankful, traumatized, sad, angry or proud of myself*, using the response alternatives *extremely, quite a bit, moderately, a little, and not at all* (Table 2).

C1A-C1P. Thinking back to right after you had your baby (or if unconscious, after you woke up), please tell me how you felt, using the following scale, extremely, quite a bit, moderately, a little, and not at all.								
"To what extent do you feel _____ about your upcoming delivery ?"								
		Extremely	Quite a bit	Moderately	A little bit	Not at all	DK	Ref
A	Exhausted	1	2	3	4	5	8	9
B	On Cloud Nine	1	2	3	4	5	8	9
C	Disappointed	1	2	3	4	5	8	9
D	In pain	1	2	3	4	5	8	9
E	Sick	1	2	3	4	5	8	9
F	Delighted	1	2	3	4	5	8	9
G	Upset	1	2	3	4	5	8	9
H	Excited	1	2	3	4	5	8	9
I	Worried	1	2	3	4	5	8	9
J	Calm	1	2	3	4	5	8	9
K	Like a failure	1	2	3	4	5	8	9
L	Thankful	1	2	3	4	5	8	9
M	Traumatized	1	2	3	4	5	8	9
N	Sad	1	2	3	4	5	8	9
O	Angry	1	2	3	4	5	8	9
P	Proud of myself	1	2	3	4	5	8	9

Table 2. The FBS Birth Experience Scale as it looked during the telephone interviews.

A summated score was created, again with some items reversed, such that the higher the score the more positive women were about their birth experience. Scores could



range from 16 to 80 and the Cronbach's  $\alpha$  was 0.73. Scores on the FBS Birth Experience Scale (FBS-BES) ranged from a low of 28 to a maximum of 80. The mean score was 68.7 and the median was 70. Those in the lowest quintile (19.8% of the study population) had scores ranging from 28 to 64.

Compared with the population comparison group, the women who participated in the FBS were older, more often white, had higher education, had more often private insurance, and were more often white (Table 3)<sup>121</sup>.

Table 3. Study sample in comparison to population of first, singleton births among women aged 18-36 in Pennsylvania in 2008 <sup>121</sup>			
Characteristics	Study Sample (%) (n=3006)	Population (%) (n=43 430)	P-value
Mode of delivery			0.100
Normal vaginal	62.6	61.1	
Instrumental vaginal	8.7	8.9	
Caesarean	28.7	30.0	
Maternal age (years)			<0.001
18–24	27.0	46.2	
25–29	39.7	31.0	
30–36	33.3	22.9	
Race/ethnicity			<0.001
White	83.2	76.0	
Black	7.4	13.2	
Hispanic	5.5	5.8	
Other	3.9	5.0	
Education			<0.001
High school degree or less	16.7	36.2	
Some college or technical	26.7	28.9	
College grad or higher	56.6	34.8	
Insurance			<0.001
Private	76.7	64.8	
Public	22.9	29.8	
Self-pay	0.4	5.5	
Marital status			<0.001
Married	70.4	52.5	
Not married	29.6	47.5	

## 4.4 PAPER IV

As with paper I and II, this study is based on data from the Swedish Medical Birth Register. We initially selected a cohort of 805 820 women who had their first delivery between 1992 and 2010 and followed them until December 31, 2010. Exclusion criteria were women with multiple births, stillbirths, missing or incomplete information and forceps delivery. We ended up using data from 771 690 women.

In this study we:

- used the outcome variables: probability of giving birth to a second infant, probability of giving birth to a third infant, and interpregnancy interval.
- used Cox's proportional hazards models to study the associations between a woman's primary mode of delivery and the outcomes;
- stratified women into three different age categories (<25, 25-34 and >34 years) to show how a primary VE affects women differently depending on age;
- adjusted for potential confounders such as age, body-mass index (BMI), height, morbidity and infertility problems.

### ETHICAL APPROVALS

The studies in this thesis were approved by the regional ethics committee in Stockholm. Paper III was also approved by IRB, USA.

Paper I: 2008/1322-31

Paper II: 2008/1322-31

Paper III: IRB 25732 and 2012/1017-31/3

Paper IV: 2011/195-31/2 and 2013/2155-32

## 4.5 STATISTICAL METHODS

### *Chi square test*

The chi-square ( $\chi^2$ ) test is used to determine whether there is a significant difference between expected and observed frequencies in one or more categories. This test was for example used in study III to investigate maternal characteristics by level of fear of birth.

### *Logistic regression*

Logistic regression is a statistical procedure which attempts to predict the values of a given variable, (termed the dependent, outcome, or response variable) based on the values of other variables (called independent variables, predictors, or covariates). With multiple logistic regression one can model the relationship between a dependent variable 'x' and several explanatory variables 'y1', 'y2', 'y3' etc, and thereby adjust for confounding factors. The results are then usually presented

as odds ratios (OR) with confidence intervals (CI). An odds ratio is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. The CI indicates the level of uncertainty around the OR. By having an upper and lower confidence limit we can infer that the true population effect lies between these two points. In the studies in this thesis the 95% CI is reported which is also most common. Logistic regression was used in all four studies in this thesis.

#### *Cox proportional hazards model*

Cox proportional hazards model, which was used in paper IV is a survival model and the most commonly used model in medical time-to-event studies.<sup>127, 128</sup> The model relates the time that passes before some event occurs to one or more covariates that may be associated with that quantity of time. One or more predictor variables, called covariates, are used to predict the outcome variable or event. In this case, we studied the time from the first event (which was a primary birth) to next event (a second birth). The central statistical output is the hazard ratio (HR). Hazard is the risk of an outcome in a certain time interval, assuming “survival” to that time. The hazard ratio is the relative hazard, when two groups, exposed (in this case to VE) and unexposed (SVD), are compared and assumes proportional hazards.

The analyses conducted and reported in this thesis were computed using IBM SPSS 19.0 (paper II), IBM SPSS 20.0 (paper I and III) and StataIC12 (paper IV).

## 5 RESULTS

This is a summary of the results. For a complete presentation, please see the individual studies at the end of the thesis.

### 5.1 PAPER I

Several factors were associated with VE and EmCS rates, including maternal age, BMI, height, pregestational diabetes, gestational diabetes, preeclampsia, gestational length, sex, birth weight and head circumference. As maternal age and height had high impact on the probability of VE and EmCS, it is noteworthy that these two variables alone alter the absolute risk of vacuum extraction from as few as 1 in 14 pregnancies (among women aged less than 25 years with a height of at least 176 cm) to 1 in 5 pregnancies (among women aged 40 years or more with a height of 155 cm or less). The probability of EmCS ranged, by similar combinations of maternal age and height, from 1 in 43 pregnancies to 1 in 8 pregnancies, respectively.

Maternal country of origin and whether the woman lives with her partner or not were associated with VE but not EmCS. We found that depending on the risk factors, the odds of being delivered by VE can vary immensely from one woman to another.

Increasing maternal age explains a substantial fraction of the increase in VE use since 1992. Increased use of epidural anesthesia is also a contributing factor. Compared with 1997, the OR of a VE due to a *non-reassuring fetal status* was increased in 2010, both among women with and without epidural anesthesia (Table 4, circled in red).

Table 4. Adjusted OR and 95% CI for vacuum extraction in 2010 vs. 1997, based on indication and use of epidural analgesia. Primiparous women in Sweden 1997-2010.						
	Crude	Model 1	Model 2	Model 3	Model 4	
No EDA						
All women	1.22 (1.14-1.30)	1.13 (1.06-1.21)	1.13 (1.06-1.21)	1.16 (1.08-1.24)	1.17 (1.09-1.26)	
Due to FD	1.80 (1.70-1.92)	1.69 (1.59-1.80)	1.68 (1.59-1.79)	1.66 (1.56-1.77)	1.62 (1.52-1.73)	
Due to PL	1.04 (0.98-1.11)	0.91 (0.85-0.96)	0.91 (0.86-0.97)	0.92 (0.86-0.98)	0.92 (0.87-0.99)	
EDA						
All women	1.13 (1.08-1.19)	1.03 (0.98-1.09)	1.03 (0.97-1.08)	1.01 (0.96-1.07)	1.01 (0.95-1.07)	
Due to FD	1.58 (1.48-1.68)	1.44 (1.35-1.54)	1.42 (1.33-1.52)	1.42 (1.32-1.52)	1.41 (1.31-1.51)	
Due to PL	0.82 (0.78-0.86)	0.73 (0.70-0.77)	0.74 (0.70-0.77)	0.73 (0.70-0.77)	0.73 (0.69-0.77)	
Model 1. Adjusted for maternal age						
Model 2. Adjusted for all of above + induction of labor						
Model 3. Adjusted for all of above + height + preeclampsia + pregestational diabetes + gestational diabetes						
Model 4. Adjusted for all of above + birthweight + head circumference						
EDA= Epidural analgesia FD= Fetal distress. PL= Prolonged labor						

## 5.2 PAPER II

As hypothesized, the size of the newborn infant's head had a large impact on the course of labor. The increase in risk of VE or EmCS is nearly linear with the increase in head circumference (Fig 2). For instance, the proportion with women diagnosed with prolonged labor increased from 14% among those with infants with the smallest head circumference (28-32cm) to 38% among those with the largest (39-41cm), and the proportion of women having a vacuum extraction increased from 9% to 35% (head circumferences 28-32cm and 39-41cm, respectively). When predicting the risk of VE, the head circumference plays a more important role than birth weight.

The results of attributable risk proportions showed that 46% of the VE and 39% of the CS in the group with head circumference 37–41 cm could be related to the large head circumference compared with a 9 and 7% attributable risk in the population.

The relation between increasing head circumference and the outcomes were similar in infants with low ( $\leq 3000$  grams) and high ( $\geq 4000$  grams) birth weight. However, the prevalence of the diagnosis *non-reassuring fetal status* increased more rapidly in relation to head circumference in the low birth weight infants.

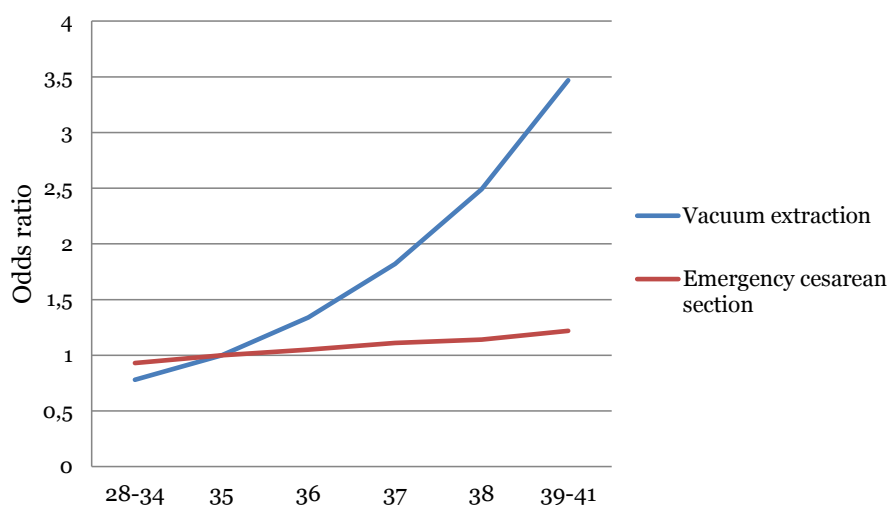


Fig 2. Odds ratio for vacuum extraction and emergency cesarean section in relation to head circumference(cm). Primiparous women in Sweden 1999-2008 (n=359 184).

### 5.3 PAPER III

Among the participants in the First Baby Study (FBS), 1882 women had a SVD, 314 had an instrumental vaginal delivery (77 forceps, 249 VE, 12 both forceps and VE), 708 women delivered by EmCS and 261 had a planned cesarean section.

A larger proportion of women with high levels of fear (highest score quintile) of the upcoming birth were young (18–24 years), black, had low social support, were unattached (to the father-to-be or partner), were living in poverty or near poverty, and had unplanned pregnancies.

In women with high fear, rates of a negative birth experience increased from 24% among women with a SVD to 44% among women with emergency cesarean section. A slightly larger rate difference in negative birth experience was observed among women with intermediate fear: from 14% among women with a non-instrumental vaginal delivery to 36% among women delivered by emergency cesarean section, thus an increase of a negative birth experience by 22%. Among women with low level of fear, corresponding rates were 6% and 15%, and the rate difference was only 9% (Figure 3).

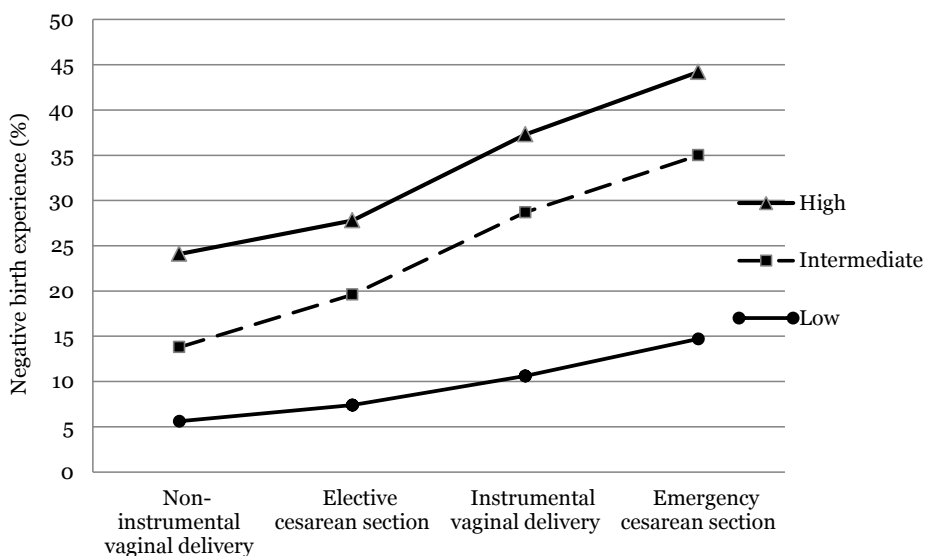


Fig 3. Unadjusted rates of a negative birth experience (highest quintile) by level of fear of labor and mode of delivery

Compared with women who had a non-instrumental vaginal delivery, risks of a negative birth experience were increased among women with ELCS, VE and EmCS. In the table below, the groups of women with high fear who delivered by VE or EmCS are circled in red. Compared to women with a low level of fear and a SVD (circled in blue), these women had a 10- and 12-folded increased risk of reporting a negative birth experience, respectively.

Table 5. Maternal fear of birth and mode of delivery and risk of having a negative birth experience*.						
Mode of delivery	Fear of childbirth					
	Low		Intermediate		High	
	No <sup>a</sup>	OR <sup>b</sup> (95% CI)	No <sup>a</sup>	OR <sup>b</sup> (95% CI)	No <sup>a</sup>	OR <sup>b</sup> (95% CI)
Non-instrumental vaginal delivery	443	1.00 <sup>c</sup>	1060	2.52 (1.62-3.92)	378	5.13 (3.20-8.23)
Elective cesarean section	27	1.30 (0.29-5.83)	92	3.80 (1.96-7.36)	36	5.99 (2.57-13.95)
Instrumental vaginal delivery	66	1.96 (0.81-4.76)	136	6.11 (3.50-10.65)	59	10.35 (5.25-20.39)
Emergency cesarean section	156	2.99 (1.63-5.46)	414	8.48 (5.38-13.37)	138	12.25 (7.19-20.86)
*Includes the quintile (20%) of women with the most negative birth experience Abbreviations: CI, confidence interval. <sup>a</sup> No. Denotes number of women included in the analyses <sup>b</sup> OR denotes odds ratios, which are adjusted for social support, education and planned pregnancy. <sup>c</sup> The women in this group served as the reference group.						

## 5.4 PAPER IV

Compared with women with a primary spontaneous vaginal delivery, women with a VE had a slightly lower probability of having a second delivery (HR 0.96, 95% CI 0.95–0.97). Women delivered by EmCS or ElCS had even lower probabilities of a second delivery (HRs 0.85, 95% CI 0.84–0.86 and 0.82, 95% CI 0.80–0.83, respectively). Adjustments for BMI, height, maternal morbidity infertility or birth weight did not substantially influence the probability of a second delivery as a function of an instrumental first delivery.

Of women with a primary spontaneous vaginal delivery, 80.4% had a second childbirth within 5 years, whereas the corresponding rate for women with a primary VE was 76.8%, and rates for women with EmCS and ElCS 70.3 and 65.7%, respectively (Fig 4).

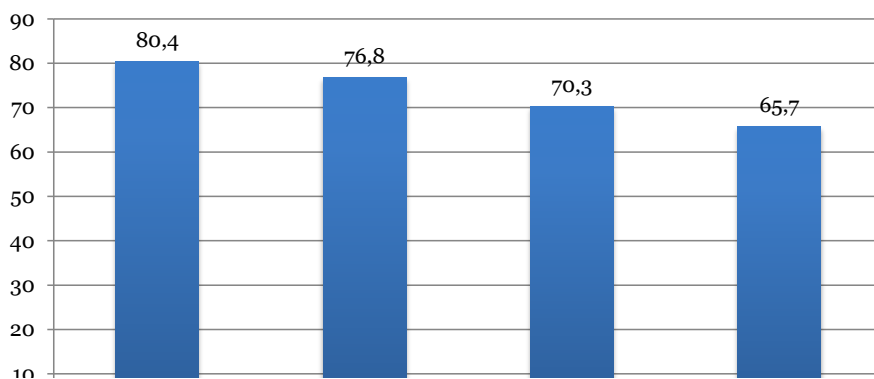


Fig 4. Mode of delivery and percentage of women who had a second childbirth within 5 years.

There were statistically significant differences in median interpregnancy interval between first and second pregnancy in relation to mode of delivery. However, it is questionable whether these differences are clinically relevant. Compared with women who had a primary SVD, the interpregnancy interval was only 8 days longer for women with a VE and 43 days longer for women with primary elective or EmCS.



## 6 GENERAL DISCUSSION

### 6.1 METHODOLOGICAL CONSIDERATIONS

All four studies included in this thesis are observational studies. In evidence based medicine, randomized controlled trials are considered to provide the highest degree of evidence<sup>129</sup>, and are therefore considered to be the ultimate gold standard for evaluations in health care. However, issues with RCT trials such as non-compliance, crossover effects and external validity warrant consideration in the translation of findings from the trials to widespread clinical practice. The need for observational studies can be justified on several grounds<sup>130, 131</sup>. Most importantly, everything is not possible to study using experimental design: experimental studies may not be feasible due to ethical, legal, political or practical reasons.

The common strengths of paper I, II and IV were the use of national registers and the prospective collection of data, minimizing the risk of selection and recall bias. Based on the designs of the studies and thanks to the extensive Swedish Medical Birth Register (MBR), we were able to adjust for a number of confounding factors and also account for possible mediating factors. The sizes of the studies make chance an unlikely explanation for our findings. In study III, the information was also prospectively collected, but the study is not population-based and more prone to be biased by selection (further discussed under *internal validity*). A strength in study III is that “soft” variables, such as planned pregnancy, fear of birth and birth experience were collected. Such variables are not available in the Swedish registries, and the study would have necessitated a new data collection. The large sample size in the FBS made it possible to study fear of birth and birth experience in subgroups which is not common in this area of research.

As with all observational studies, we cannot draw conclusions about causation. The variables used in the studies are not always of excellent quality, we did not have access to all potential confounding variables that might be of importance, and last but not least, there are potentially other confounding

*Hills Criteria of Causation* <sup>5</sup> outlines the minimal conditions needed to establish a causal relationship between two items.

1. Strength of association: the higher the OR or RR the stronger the association
2. Temporality: cause must precede effect
3. Consistency: multiple studies showing the same finding increases the credibility of the finding
4. Biological plausibility: there must be a rational and theoretical basis for the finding
5. Dose response relationship: greater amounts of exposure should result in greater amounts of harm
6. Experimental evidence: experiments make a causal inference more plausible

variables that we are unaware of today. Findings in a study can be evaluated using Hills Criteria of Causation<sup>5</sup>.

### *Clinical relevance*

When working with large datasets as in Paper I, II and IV, it is easy to come across statistically significant results (unlikely to be due to chance), and yet the deviation from the null hypothesis may be too small to be of any clinical interest. A statistically significant result refers to a  $p\text{-value} < 0.05$  (there is only a 5% chance that a difference of the size found in your study would occur by chance alone, if there was actually no difference in the whole population) or an odds ratio (OR) with a confidence interval (CI) that does not cross 1. Now what is a clinically relevant result is a different story.

For example, in Study IV we identified a statistically significant difference in the interpregnancy interval (IPI) between women who deliver their first child by VE and those who have a primary SVD. The  $p\text{-value}$  was  $<0.005$  which indicates that there is a true difference. However, the actual difference in days was 8 which does not have any clinical importance.

It is up to the clinician to decide the clinical relevance of results in epidemiological studies. It is not always easy to set a cut-off value and say that at this point it starts to matter. Whether the results are clinically relevant has to be based on clinical judgment, magnitude of benefit of each treatment, costs, patient's preferences etc. To illustrate the clinical importance of statistical findings, the results can be presented in terms of numbers needed to treat.

### *Internal validity*

Internal validity means that the study measured what it was set out to measure<sup>132</sup>.

Internal validity is influenced by selection bias, classification bias, and confounding, which are present to some degree in all observational research. Therefore one has to be careful in drawing conclusions about causation in observational studies. Selection bias stems from an absence of comparability between groups being studied. Classification bias results from incorrect determination of exposure or outcome or both. Confounding is a mixing or blurring of effects. A researcher attempts to relate an exposure to an outcome, but actually measures the effect of a third factor, termed a confounding variable. A confounding variable is associated with the exposure and it affects the outcome, but it is not an intermediate link in the chain of causation between exposure and outcome.

Population-based studies (Study I, II and IV) reduce the risk of selection bias as the whole population is selected. However, participation studies such as study III are at

higher risk of selection bias, as women were recruited individually. Participants who choose to participate in a study tend to be more educated and affluent individuals than in the general population, as seen in our study. As table 3 shows, the cohort of women captured in the First Baby Study differ from the population in age, BMI, race, education and marital status. This needs to be taken into consideration when generalizing the results. In study III, the aim was not to compare the women in the cohort to the rest of the population but the comparisons were made within women in the cohort. Therefore, the selection bias in the First Baby Study should not influence internal validity, but may influence generalizability to women outside the cohort.

In the present population-based studies (I, II and IV), misclassification of exposures and outcomes is impossible to rule out. The clinical diagnosis of prolonged labor and most likely the diagnosis of fetal distress might be affected by a degree of subjectivity in assessment. Furthermore, these diagnoses might be defined differently in younger and older women. Increased vigilance in the surveillance of older women could infer an overestimation of dystocia and fetal distress<sup>133</sup>. Other classifications of exposures and outcomes (such as head circumference, birth weight, gestational age, mode of delivery) should be of fairly good quality according to validation studies of the Swedish Medical Birth Register<sup>3, 120</sup>.

In any study that relies on memory there is a risk of recall bias. In study III, women were asked one month (on average) after giving birth about their experience immediately after delivery. It is impossible to rule out that memories of birth had changed. If memories have changed differently by exposure groups (level of fear of birth or mode of delivery), there is a clear risk of recall bias.

Confounding can be controlled in several ways: restriction, matching, stratification and through multivariate techniques <sup>132</sup>. In study I, II and IV we used restrictions to increase the homogeneity of the study population. For example in study I and II we avoided known confounding by restricting the samples to nulliparous women with term singleton pregnancies in cephalic presentation and excluded stillbirths. In study I, we avoided confounding by stratifying for the use of EDA. In study II, we stratified for low and high birth weight babies. In all four studies, multivariate techniques were used in order to control for potential confounding variables.

### *External validity*

External validity is the ability to generalize the findings to other study populations<sup>132</sup>. Study I and study IV are based on a Swedish sample of women giving birth. The studies bring forward the praxis of antenatal care, labor and delivery in Sweden, which differs from many other countries. We are able to draw conclusions on the use of VE in Sweden and how Swedish women react to a VE or a cesarean delivery with respect to subsequent childbearing based on the culture and health care we have in

this country. The results can not immediately be generalized to a population in a different country, but can give an indication of how it might be in a similar sample elsewhere.

Study II is however more of an etiological nature, and one may argue that the external validity of this study is higher. There is no reason to believe that a greater head circumference would not cause problems in labor in another population.

Study III is based on a much selected sample of women in Pennsylvania, USA, and the characteristics of included women may differ to the rest of the US and other parts of the world. Mode of delivery, levels of fear of birth and a negative birth experience may also differ between populations. However, the findings in Study III are congruent with previous research indicating that fear of birth and mode of delivery, likely influence birth experience also in other settings <sup>24, 99, 110, 111, 113, 114</sup>.

### *Interaction*

Interaction is present when the effect measure (in this thesis OR) of one variable, varies across values or strata of another explanatory variable. In practice, an interaction becomes evident when the joint effect of two factors deviates from what would be expected under the assumption of no interaction. For example, in paper I, we knew that the use of EDA had changed over time so we examined statistical interaction by introducing an interaction term (EDA\*year of birth) into the regression model. Since this term was significant we then choose to stratify women into two groups, EDA yes/no. In paper IV, we noted an interaction effect between VE and age on the outcome (a second delivery). We then choose to stratify for age in a separate analysis to control for this confounding effect.

## **6.2 FINDINGS AND IMPLICATIONS**

### *Paper I*

The results of study I show that the risks of VE can vary immensely from one woman to another depending on maternal and fetal characteristics. Maternal age has been increasing in Sweden and other western countries<sup>35, 134</sup>. High maternal age is a strong risk factor for many complications during delivery, such as labor dystocia<sup>50</sup>, asphyxia<sup>51</sup> and increased rates of EmCS<sup>50, 53, 135, 136</sup>. It can be discussed whether these risks are explained by age per se, or by medical complications and interventions increasing with maternal age.

A surprising finding in this study was that obesity is not a risk factor for VE, considering that obesity increases the risk of EmCS<sup>137, 138</sup>. However, obese women are more often delivered by cesarean section in the first stage of labor. If they reach the

second stage of labor, their chance of non-instrumental delivery is as good as in normal weight women.

We could partly explain the increase in VE use over time by increasing maternal age and increased use of EDA. The prevalence of the diagnosis *non-reassuring fetal status* has increased over time and contributed to more extractions. This applies both to women with and without EDA. It is unclear if fetuses in fact are more distressed today than in 1997, or if they are perceived to be more distressed. Both explanations are realistic and plausible as:

- 1) The use of oxytocin augmentation has increased (both among women with and without EDA) over the last two decades, which can perhaps imply an increased prevalence of the diagnosis *non-reassuring fetal status* and possibly also influence the prognosis for the infant<sup>139</sup>. Oxytocin augmentation is used to induce and shorten labor and are more commonly administrated to women with EDA. Thus, as the rate of EDA use has increased in nulliparous women (from 22% in 1992 to 50% in 2010), so has the rate of oxytocin augmentation.
- 2) The second explanation related to our perception of fetuses in distress is supported by the fact that continuous cardiotocography (CTG) is used more widely today than two decades ago. Continuous CTG is associated with more interventions during labor, including VE and EmCS<sup>140</sup>. During the last twenty years it has been a continuing focus on the interpretation of fetal heart rate (FHR) patterns and obstetricians and nurse-midwives are today taught to classify FHR patterns into risk categories<sup>141</sup>. The intervention rate during labor due to fetuses assessed to be distressed is increasing, however the actual prevalence of neonates with birth asphyxia remains stable<sup>41, 142</sup>. Perhaps the increased prevalence of non-acidotic babies delivered VE and EmCS reflect a lack of understanding of how the fetus defends itself, compensates for intrapartum hypoxic ischaemic insults, and the ability to recognise the patterns that suggest loss of compensation.

## *Paper II*

It is accepted that the duration of labor and the second stage increases with increasing fetal size. Also, the needs of oxytocin augmentation, VE and EmCS are greater. In line with a couple previous studies<sup>143, 144</sup>, we were able to show that the postpartum head circumference is a fairly good predictor of complications during labor. However, it is problematic that neonatal head circumference only can be obtained following delivery and has no predictive value for interventions in labor.

The results of this study highlight the importance of the size of the fetal head on labor outcome. Neonatal head circumference was a stronger predictor of VE than birth weight. In future research, it should be possible to study associations between

ultrasound assessment of fetal head size at the onset of labor (or late in pregnancy) in relation to risks of dystocia and VE.

A question worth discussion is how to handle the information of a large head circumference early in labor. Our results showed that 50% of the mothers with an infant with a head circumference of 39-41cm have a SVD. So, a large head circumference does not equal complications and these women should receive a fair chance to deliver spontaneously. However, if a VE is performed on an infant with a known large head circumference and the presenting part does not follow the tractions, perhaps the obstetrician should discontinue the attempt early and choose EmCS as the method of delivery. Perhaps the knowledge of the importance of head circumference can be viewed upon as another piece in the puzzle of risk estimation among women in labor. An additional study idea may be to use registry data and compare the importance of neonatal head circumference in VE deliveries: is a large neonatal head size a predictor of an unsuccessful VE (ending in EmCS)?

### *Paper III*

The findings in this study have contributed to the understanding of how important fear of birth and mode of delivery are for the birth experience. The study is unique because it shows the interplay between the different combinations of level of fear and mode of delivery and birth experience. For example, we were able to show that compared to women with intermediate and high levels of fear, women with low levels of fear rarely have a negative birth experience, disregarding mode of delivery.

An ElCS was shown not to necessarily be the best alternative for women with high levels of fear, which support findings by others<sup>24, 102</sup>. Women with fear of birth can actually be cured by a SVD<sup>145</sup>. This is an important aspect in the counselling of women with fear of birth in subsequent pregnancy. An ElCS is not necessarily the solution to fear of birth<sup>103, 146</sup>. In Sweden, there is an agreement about this, and there are also national guidelines regarding maternal request of cesarean section<sup>33</sup>.

The question remains of what we can do to help women from having fear of birth or a negative birth experience, besides limiting unnecessary interventions during

Each technological intervention needs to be considered not only for its medical risks and benefits but also for its effect on the birth experience.<sup>1</sup>

labor. For the past 25 years in Sweden, women with antenatal fear have received counseling in order to lower their fear and prepare for the upcoming birth. But even though a lot of women report the counseling to be helpful<sup>147</sup>, the evidence in favor of such treatment is not overwhelming<sup>145, 147</sup>. There is far more evidence to show the benefits of one-to-one care and continuous support during labor. In a systematic review<sup>148</sup> it was concluded that women who received continuous labor support were more likely to have a positive birth experience, they were less likely to use pain medications, were more likely to give birth non-instrumentally and had slightly

shorter labors. It was stated that all women should have continuous support during labor.

There are limitations in study III. The FBS Birth Anticipation Scale and FBS Birth Experience Scale used to measure fear of birth and birth experience in this study were newly developed by the researchers. This limits the possibilities of comparisons of results from previous studies of rates of fear of birth or rates of a negative birth experience. Since fear of birth and birth experience are such complicated and multifactorial variables, the rates can vary immensely depending on the instrument used. For analytical reasons and based on previous research<sup>81-95</sup>, we assumed that the 20% of women with the highest scores on the the FBS Birth Anticipation Scale had a high fear of birth and that the 20% with the lowest scores on the FBS Birth Experience Scale had a negative experience. It would have been more rewarding to use a validated and more commonly used instrument such as Wijma Delivery Expectancy Scale Versions A and B, which would have given us rates to compare internationally<sup>149</sup>. However, it is reassuring that the findings in this study are in line with previous research and the internal reliability of the instruments was acceptable.

Another limitation was that we did not account for all factors that could have had a confounding or a mediating effect on the results. For example we did not include length of labor, support during labor or other complications during labor, all of which may have affected the progress of labor and birth experience. Instrumental delivery or CS can serve as proxies for prolonged labor and a prolonged labor has by itself shown to contribute to a negative birth experience<sup>150</sup>.

#### *Paper IV*

Compared with women with a primary SVD, women with a first delivery by VE had a 4% lower probability of having a second child. The corresponding rates for EmCS and ElCS were 15% and 18%, respectively. Our findings are in agreement with a recent population-based study in Denmark which reported identical results for VE deliveries and a 4% lower probability of a second birth<sup>151</sup>. In regards to subsequent childbearing, VE may offer advantages over EmCS.

There are at least three possible explanations why women with a primary VE have less subsequent childbirths than women with a primary SVD. Women with operative deliveries (especially CS, but possibly also VE) constitute a group of women with predisposing infertility problems or may undergo biological changes as a result of the operation, leading to fewer consecutive children.<sup>152</sup> The second and more plausible explanation is that prolonging or abstaining from a second pregnancy after a primary delivery by VE may be a voluntary choice. A primary VE has previously been associated with a traumatic birth experience, which in turn has been associated with fewer subsequent deliveries<sup>11, 24, 145</sup>. Thus, a woman with a primary traumatic operative delivery may change her childbearing plans<sup>11, 24</sup>. Third, women with a primary VE may also be a selected group; these women may be less

likely to have a second child even before the first birth. In a previous study<sup>121</sup>, only 85% of the women who underwent a primary delivery by VE had a pre-delivery intention of having one or more children after the first one, compared with 91% among those with a SVD or 90% among women with EmCS or ElCS.

There has been decreasing use of VE in many regions in high income countries whereas the rate of CS has increased<sup>67, 153</sup>. However, the lack of decreases in maternal or neonatal morbidity or mortality raises significant concern that CS is overused. It is important for health care providers to understand the short-term and long-term tradeoffs between cesarean and vaginal delivery, as well as the safe and appropriate opportunities to prevent overuse of CS, particularly primary CS.

With respect to subsequent childbearing, it is not acceptable to perform an EmCS on women who are eligible for VE. All obstetricians should be trained in the use of a vacuum extractor and it should be the first line method of delivery when delivery needs to be expedited and inclusion criteria are met. An EmCS in a nulliparous woman should be regarded as a safe procedure, even though some adverse effects should not be neglected such as an increased hemorrhage<sup>154</sup>, puerperal infections and thromboembolism<sup>155</sup>. However, CS among nulliparous women are of particular interest as the first delivery is crucial for the outcome of subsequent deliveries.



## 7 CONCLUSIONS

- Depending on risk factors, the odds of being delivered by VE can vary immensely from one woman to another. Increasing maternal age explains a substantial fraction of the increase in VE use since 1992 (Paper I).
- The indication *non-reassuring fetal status* is used more liberally today in VE deliveries than in 1997. This applies to both women with and without EDA. It is unclear if fetuses in fact are more distressed today than in 1997, or if they are perceived to be more distressed (Paper I).
- Odds of prolonged labor, non-reassuring fetal status, maternal distress, VE and EmCS gradually increase as fetal head circumference increases (Paper II).
- A neonatal head circumference of 37-41cm is an explanatory factor to almost half of the assisted vaginal births and one-third of all EmCS (Paper II).
- Both levels of fear of childbirth and mode of delivery are important for the birth experience (Paper III).
- With respect to birth experience, a SVD was a better alternative for the study participants with high levels of fear, compared with a ElCS (Paper III).
- Women who delivered by VE in Sweden 1992-2010 had a 4% lower probability of having a second childbirth, compared with women with a primary SVD (Paper IV).
- A primary ElCS or EmCS are associated with a 18% and 15% lower probability of having a second childbirth compared with women with a primary SVD (Paper IV).

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## 8 FUTURE RESEARCH

- In studies I and II we found that a number of factors were associated with risks of VE or EmCS. However, other factors, including genetic factors are important for birth outcomes and probably also for mode of delivery. Full sisters share 50% of their segregating genes and are generally also brought up together. A case control study of sisters (discordant for VE or discordant for EmCS) is a potential method to study whether the influence of common risk factors for VE or EmCS is independent of familial (shared genetic and early environmental) factors.
- Head circumference is strongly associated with complications during labor. However, head circumference, which is measured after birth, is most likely influenced by progress of labor. The association between ultrasonic measurements of biparietal diameter (BPD) before labor and risk of instrumental delivery should be evaluated. In women with an ultrasonic scan during the last month of pregnancy, it should be possible to study associations between BPD and VE and EmCS. Such information may be useful in clinical practice, for example when planning for childbirth or counseling patients requesting an ElCS due to fear of birth.
- It is of interest to study how obstetric anal sphincter rupture influence birth experience and subsequent childbearing. This research question could be answered by using data from the First Baby Study.
- We found that women with a primary delivery by VE, ElCS or EmCS have a lower probability of having a second child compared to women with a primary SVD. Register based sister studies can be performed to exclude that these risks are independent of genetic and/or early environmental factors shared by the sisters.
- In countries, regions or hospitals where the use of VE is declining, research is needed to evaluate the consequences. Skills of VE among physicians should be evaluated and women who “unnecessarily” were delivered by EmCS rather than VE should be interviewed in-depth.
- A negative birth experience after a primary VE can lead to a maternal request of ElCS in next pregnancy. Risks of repeat VE and/or failed vaginal delivery after a primary VE should be evaluated as this information may be useful in counseling of these patients. Register based studies using the MBR can be performed to study mode of delivery and other medical outcomes after a primary VE.

## 9 POPULÄRVETENSKAPLIG SAMMANFATTNING

Förlossning med sugklocka (vakumextraktion) kan bli aktuell då förlossningen har avstannat eller om barnet snabbt behöver komma ut för att det visar tecken på att inte må bra. För att sugklocka ska kunna användas måste vissa kriterier vara uppfyllda (t ex fullvidgad livmodertapp, vattenavgång och barnets huvud ska ha trängt långt ner i förlossningskanalen). Om kriterierna inte är uppfyllda och förlossningen behöver avslutas görs ett kejsarsnitt.

Ungefär 14% av alla kvinnor som föder sitt första barn i Sverige gör detta med hjälp av sugklocka. I de nordiska länderna har vi en relativt hög andel sugklockor jämfört med t ex USA, Australien och andra länder i Europa som har en låg andel i många regioner eftersom de av olika anledningar istället väljer att göra kejsarsnitt.

Det finns vissa risker med att använda sugklocka. Kvinnan kan få stora bristningar som leder till inkontinens, hon kan blöda mer och barnet kan i sin tur få skador utanpå och inuti huvudet. Trots att dessa komplikationer förekommer så har forskning visat att skadorna är så pass ovanliga eller lindriga att en korrekt utförd extraktion med sugklocka kan bedömas som ett säkert ingrepp och är ett bra alternativ till ett akut kejsarsnitt.

Det har skett en ökning av andelen sugklockor från ca 10% år 1990 till 14% år 2010 i Sverige och det är oklart varför. Eftersom det samtidigt skett en ökning av andelen kejsarsnitt (som är ett större och mer allvarligt ingrepp) så har forskningen fokuserats på kejsarsnitten och sugklockorna har hamnat i skymundan. Det har därmed funnits en kunskapslucka om förlossningar med sugklocka och därför uppstod denna avhandling för att besvara några av de frågor som fanns.

Vi har studerat:

- vilka maternella och neonatala riskfaktorer som kan förknippas med en förlossning med sugklocka (Studie I).
- varför vi använder sugklocka oftare idag än för tjugo år sedan (Studie I).
- vilken betydelse barnets huvudomfång har för risken för sugklocka (Studie II).
- hur kvinnor som föder med sugklocka upplever sin förlossning i relation till hur rädda de är innan födseln (Studie III).
- om kvinnor som föder sitt första barn med sugklocka i lägre utsträckning föder ett barn till eller väntar längre med nästa barn jämfört med kvinnor som föder sitt första barn spontant vaginalt (Studie IV).

För att kunna besvara dessa frågeställningar använde vi oss både av Medicinska Födelseregistret (Studie I, II och IV) samt av en datainsamling som gjorts på 3006 förstföderskor i Pennsylvania, USA (Studie III).

Vi fann att risken för förlossning med sugklocka ökar med mammans ålder, barnets huvudomfång och vikt, medan risken avtar med ökande längd hos modern. Ytterligare faktorer är om mamman har diabetes, preeklampsi (tidigare kallat havandeskapsförgiftning), blir igångsatt för att föda eller använder ryggbedövning. Kvinnor som lider av obesitas, dvs. har ett BMI  $\geq 30$  har inte en ökad risk för sugklocka men däremot för akut kejsarsnitt. Många gånger når obesa kvinnor inte utdrivningsskedet eftersom de kejsarsnittas under öppningsskedet på grund av dåligt värkarbete.

I studie II kunde vi se att risken för sugklocka och andra komplikationer så som kejsarsnitt, lång förlossning och stressat barn i magen ökar i takt med att huvudomfånget stiger. Jämfört med de barn som har ett genomsnittligt huvudomfång (35cm) så löper de med ett huvudomfång på 37cm en nästan dubbelt så stor risk för sugklocka.

I studie III kunde vi se att kvinnor med låg rädsla inför födandet kunde hantera en förlossning med sugklocka eller akut kejsarsnitt mer positivt än de som hade hög förlossningsrädsla. Trots att förlossningen avslutades med sugklocka så var det endast 15% bland de med låg rädsla som rapporterade en negativ förlossningsupplevelse. Av de kvinnor med hög rädsla som också födde med sugklocka eller kejsarsnitt rapporterade 44% en negativ förlossningsupplevelse. De som födde med akut kejsarsnitt hade generellt sett sämst förlossningsupplevelse och de som födde spontant vaginalt var mest positiva. Kvinnor med förlossningsrädsla som födde med planerat kejsarsnitt hade inte bättre förlossningsupplevelse än kvinnor med hög rädsla som födde spontant.

Studie IV är den första populations-baserade studien i Sverige som visar hur kvinnor påverkas i sitt barnafödande av en första födsel med sugklocka eller kejsarsnitt. Jämfört med kvinnor som föder utan sugklocka är sannolikheten för att skaffa ett till barn bland de kvinnor som fött med sugklocka något lägre (4%). Detta kan bero på att dessa kvinnor upplevde förlossningen som mer traumatisk. De som födde med kejsarsnitt hade en 15-18% lägre sannolikhet att skaffa ett till barn. Kvinnor som har fött med sugklocka föder sitt andra barn i genomsnitt 8 dagar senare än de som fött spontant vaginalt. De som har fött med kejsarsnitt (både akut och planerat) föder i genomsnitt sitt andra barn 43 dagar senare.

Kvinnor som föder både sitt första och sitt andra barn med sugklocka har inte lägre sannolikhet att skaffa ett tredje barn än de som födde sitt första barn med sugklocka och sitt andra barn spontant vaginalt.

## 10 SAMMANFATTNING FÖR BARNMORSKOR

Syftet med studierna i avhandlingen var att belysa användningen av vakumextraktion (VE) i Sverige. Vi ville studera:

- vilka maternella och neonatala riskfaktorer som kan förknippas med VE (Studie I).
- varför vi använder VE oftare idag än för tjugo år sedan (Studie I).
- vilken betydelse barnets huvudomfång har för risken för VE (Studie II).
- hur kvinnor som föder med VE upplever sin förlossning i relation till hur rädda de är innan födseln (Studie III).
- om kvinnor som föder sitt första barn med VE i lägre utsträckning föder ett barn till eller väntar längre med nästa barn jämfört med kvinnor som föder sitt första barn spontant vaginalt (Studie IV).

För att kunna besvara dessa frågeställningar använde vi oss både av Medicinska Födelseregistret (Studie I, II och IV) samt av en datainsamling som gjorts på 3006 förstföderskor i Pennsylvania, USA (Studie III).

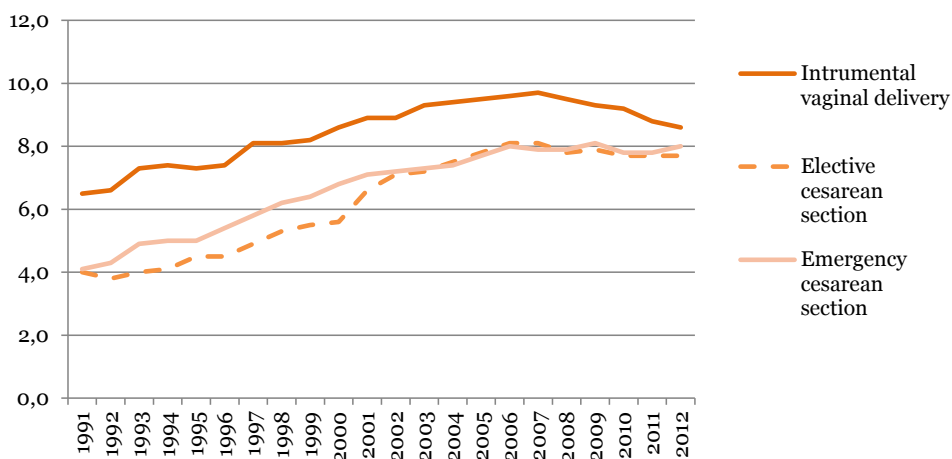
I Sverige föder ca 15% av alla förstföderskor som kommer till förlossningen med hjälp av VE, ungefär var sjunde kvinna. Alla kvinnor löper redan vid ankomst till förlossningen olika stora risker för VE. Risken ökar t.ex. kraftigt i takt med att kvinnan blir äldre och om hon är kort. Likaså om barnet är stort och/eller har ett stort huvudomfång samt om hon använder EDA. Kvinnor som lider av obesitas, dvs. har ett BMI  $\geq 30$  har inte en ökad risk för VE men däremot för akut kejsarsnitt. Många gånger når obesa kvinnor inte utdrivningsskedet eftersom de kejsarsnittas under öppningsskedet på grund av dåligt värkarbete.



## Ökningen av VE

Det har skett en ökning av andelen VE i Sverige från ca 10-14% (förstföderskor) över de senaste 20 åren och vi vet inte riktigt varför. Ökningen skiljer sig från många andra länder så som USA, Australien och andra Europeiska länder där användningen istället sjunkit de senaste årtiondena av rädsla för att barnet och kvinnan tar skada. Det finns dock ingen evidens som påvisar att det är bättre att göra ett kejsarsnitt istället för VE om situationen tillåter VE. Tvärtom så finns rekommendationer att VE ska användas i första hand för att förebygga kejsarsnitt på förstföderskor och för att komplikationerna generellt sett är lägre vid VE.

I studie I studerade vi varför ökningen av VE har skett och om den kan förklaras av maternella och/eller neonatala faktorer. Vi såg då att en stor del av ökningen kan tillskrivas den ökade andelen EDA, att genomsnittsåldern bland kvinnorna blivit högre och att vi är mer frikostiga idag med att använda diagnosen *fetal distress* som är en indikation för VE. Detta gäller både kvinnor med och utan EDA. Ungefär 11% av alla förstföderskor drabbas av komplikationen *fetal distress* under födseln, men bara ca 2% av alla de som har diagnosen under förlossningen har en Apgar <7 vid 5 min ålder.



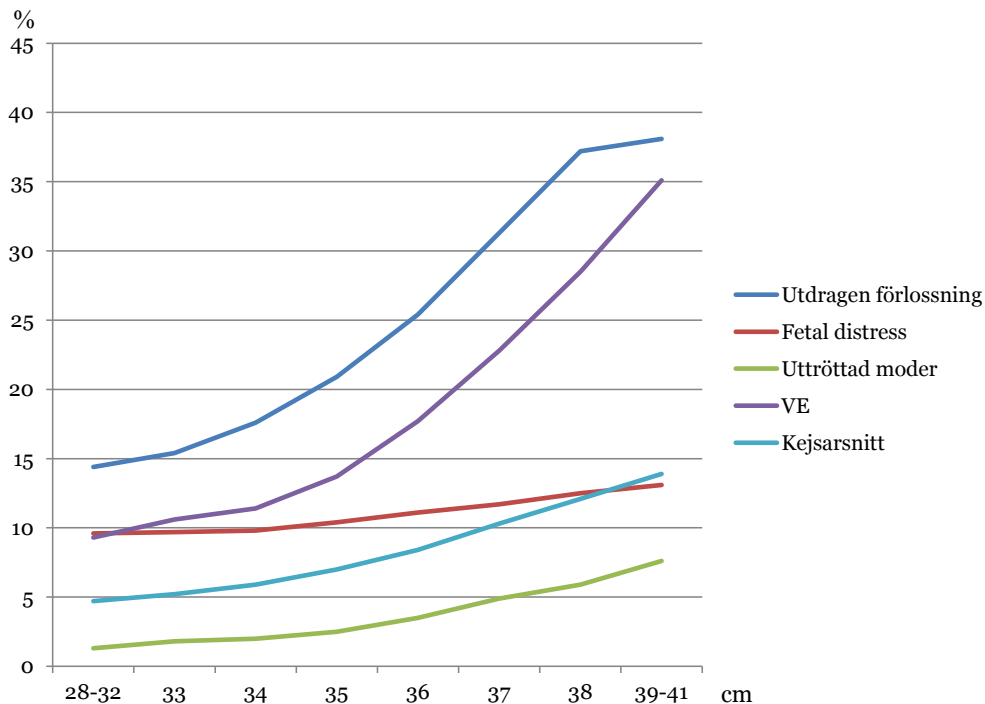
Förlossningssätt över tid i Sverige från 1991 till 2012. Alla kvinnor i Sverige.

## Huvudomfångets betydelse för komplicerad förlossning

I studie II kunde vi se att risken för VE och andra komplikationer så som kejsarsnitt, utdragen förlossning och fetal distress ökar i takt med att huvudomfånget stiger. Jämfört med de barn som har ett genomsnittligt huvudomfång (35cm) så löper de med ett huvudomfång på 37cm en nästan dubbelt så stor risk för VE. Ett problem är självklart att vi inte vet huvudomfånget förrän barnet är ute. Det finns dock

möjlighet att mäta huvudomfånget och biparietaldiameter med ultraljud innan födseln. Frågan återstår dock vad vi gör med informationen vi då får med tanke på att hälften av alla kvinnor som har barn med riktigt stora huvudomfång (39-41cm) ändå föder spontant.

Ett förslag är att huvudomfånget ses som en pusselbit när en riskbedömning för komplicerad födsel görs. Man kan spekulera i om en kvinna med stark rädsla inför födseln (och därmed redan innan födseln löper stor risk för att ha en negativ förlossningsupplevelse, se nedan) som dessutom är äldre, kort, överviktig och har ett barn med stort huvudomfång ska rekommenderas att föda vaginalt.



Förekomst (%) av komplikationer under födseln i relation till huvudomfång hos barnet.

### *Förlossningsupplevelse*

I studie III kunde vi se att kvinnor med låg rädsla inför födandet kunde hantera VE eller akut kejsarsnitt mer positivt än de som hade hög förlossningsrädsla. Trots att komplikationer tillstötte under födseln så var det endast 15% som rapporterade en negativ förlossningsupplevelse. Bland kvinnor med hög rädsla som också födde med VE eller kejsarsnitt rapporterade 44% en negativ förlossningsupplevelse. De som födde med akut kejsarsnitt hade generellt sett sämst förlossningsupplevelse och de som födde spontant vaginalt var mest positiva.

Kvinnor med förlossningsrädsla som födde med planerat kejsarsnitt hade inte bättre förlossningsupplevelse än kvinnor med hög rädsla som födde spontant.

Barnmorskan Ingegerd Hildingsson har i en av sina studier faktiskt kunnat påvisa att förlossningsrädda kvinnor kan bli "botade" genom att föda vaginalt. Problemet är att det aldrig går att garantera en icke-instrumentell födsel. Om man kan uppskatta kvinnans risker för en komplicerad födsel så kan man ta dessa i beaktande då man tar beslut om hon ska föda med planerat kejsarsnitt eller försöka föda vaginalt.

#### *Barnafödande efter en första födsel med VE*

Studie IV är den första populations-baserade studien i Sverige som visar hur kvinnor påverkas i sitt barnafödande av en första födsel med VE eller kejsarsnitt. Jämfört med kvinnor som föder spontant vaginalt så är sannolikheten att skaffa ett till barn bland de kvinnor som fött med VE 4% lägre. (En nationell dansk studie presenterade nyligen exakt samma siffra.)

De som födde med elektivt kejsarsnitt hade en 18% lägre sannolikhet att skaffa ett till barn och de med akut kejsarnitt 15% lägre. Vi tror att dessa resultat beror på att kvinnor med instrumentell förlossning upplever förlossningen som mer traumatisk och i högre utsträckning väljer att inte skaffa ett till barn. Vi kontrollerade att det inte berodde på mammans ålder, sjukdom eller infertilitet.

Kvinnor som har fött med VE föder sitt andra barn i genomsnitt 8 dagar senare än de som fött spontant vaginalt. De som har fött med kejsarsnitt (både akut och elektivt) föder i genomsnitt sitt andra barn 43 dagar senare. Vi gjorde bedömningen att denna tidsskillnad har låg klinisk relevans.

Kvinnor som föder både sitt första och sitt andra barn med VE har inte lägre sannolikhet att skaffa ett tredje barn än de som födde sitt första barn med VE och sitt andra barn spontant vaginalt.



### Take home message:

- Kvinnor har redan vid ankomst till förlossningen mycket olika förutsättningar för att kunna föda spontant vaginalt beroende på längd, ålder, vikt, gestationslängd m.m.
- Vi använder indikationen *fetal distress* oftare idag än för tjugo år sedan vid VE. Kanske mår barnen sämre idag eller så upptäcker vi det bara oftare eller så upplever vi att de mår sämre.
- Vi har en relativt hög andel VE i Sverige. Det är bra för att det hjälper oss att förebygga kejsarsnitt hos förstföderskor. Det kan vara så att vi orsakar onödiga VE genom att intervensera för mycket under förlossningens gång.
- Kvinnor som föder med VE har generellt sett en sämre förlossningsupplevelse än de som föder spontant vaginalt. De som föder med akut kejsarsnitt har generellt sämst förlossningsupplevelse. Ett elektivt kejsarsnitt är inte en självklar lösning på förlossningsrädsla.
- Hur man hanterar komplikationer under födseln beror mycket på hur man mår innan. Kvinnor med låg rädsla rapporterar sällan en negativ upplevelse.
- 4% färre kvinnor föder ett andra barn om första förlossningen avslutades med VE, jämfört med de som födde spontant vaginalt. Motsvarande siffror för akut kejsarsnitt är 15% och elektivt kejsarsnitt 18%.

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Birth is not only about making babies. Birth is about making mothers- strong, competent, capable mothers who trust themselves and know their inner strength.”

*-Barbara Katz Rothman, PhD*

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AOGS MAIN RESEARCH ARTICLE

# Reason for the increasing use of vacuum extraction in Sweden: a population-based study

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## Key words

Labor, delivery, vacuum extraction, emergency cesarean section, risk factors, epidural analgesia

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## Conflicts of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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## Abstract

**Objective.** To explain the increasing rates of vacuum extraction in Sweden. **Design.** Population-based register study. **Setting.** Nationwide study in Sweden. **Population.** A total of 589 108 primiparous women with singleton, term live births in 1992–2010. **Methods.** Odds ratios with 95% confidence intervals were estimated for potential risk factors for vacuum extraction and emergency cesarean. To explain the increase in vacuum extraction over time, we successively adjusted for maternal and infant characteristics in four different models. **Main outcome measures.** Vacuum extraction. **Results.** Rates of vacuum extraction increased from 11.5% in 1992 to 14.8% in 2010. The risk of vacuum extraction increased with maternal age and gestational length, but decreased with increasing maternal height. The increased use of vacuum extraction over time was partly explained by increasing maternal age and increased use of epidural anesthesia. Among women with and without epidural analgesia, the increase in vacuum extraction over time was confined to vacuum extraction due to signs of fetal distress. **Conclusions.** Depending on risk factors, the odds of being delivered by vacuum extraction can vary immensely from one woman to another. Increasing maternal age explains a substantial fraction of the increase in vacuum extraction use since 1992. Whether the increase in vacuum extractions due to fetal distress reflects a true increase in fetal distress during labor remains to be explained.

**Abbreviations:** BMI, body mass index; ICD-9 and ICD-10, International Classification of Diseases, ninth and tenth revisions.

## Introduction

The rate of vacuum extractions has increased during the past decades in Sweden, along with increasing cesarean section rates. From 1992 to 2010, rates of vacuum extraction increased from approximately 11.5 to 14.8% among primiparous women (1). A vacuum extraction is associated with both maternal risks [such as perineal and anal sphincter lacerations, postpartum hemorrhage and fear of childbirth (2–4)] and infant risks [such as cephalohematoma, subgaleal hemorrhage, intracranial hemorrhage and brachial plexus injury (5–7)].

In contrast to the increasing frequency of emergency cesarean deliveries (1), little attention has been directed towards factors associated with vacuum extraction. As a

## Key Message

The increase of vacuum extractions over the last decades is to a large extent explained by increasing maternal age and increased use of epidural analgesia.

consequence, the reasons for the increasing rates of vacuum extraction in Sweden during the last decades are poorly understood.

In the present nationwide Swedish study, we first investigated possible risk factors for vacuum extraction and emergency caesarean deliveries in primiparous women with singleton term pregnancies. We also investigated whether time differences in risk factors explain the increasing rate of vacuum extractions over time.

## Material and methods

The study was based on data from the Swedish Medical Birth Register, which includes more than 98% of all births in Sweden (8). Starting with the first antenatal visit, information is prospectively collected during pregnancy and delivery, using standardized records.

From 1992 to 2010, there were 1 926 778 births in Sweden. We excluded births to parous women ( $n = 1\,105\,076$ ), stillbirths ( $n = 3031$ ), multiple births ( $n = 12\,403$ ), deliveries with a gestational age  $<37$  or  $\geq 42$  completed weeks ( $n = 124\,319$ ) or no documented gestational length ( $n = 1033$ ), caesarean deliveries before onset of labor ( $n = 33\,637$ ), childbirths in non-cephalic presentations ( $n = 12\,378$ ) and those with no documented presentation ( $n = 30\,174$ ). As we wanted to study risk factors for vacuum extraction and emergency caesarean deliveries and forceps deliveries ( $n = 4675$ ), our study population was restricted to 589 108 primiparous women with spontaneous or induced onset of labor with singleton, term live births in cephalic presentation. Vacuum extraction and emergency caesarean section were used as outcomes. Failed vacuum extractions were analyzed in both groups (vacuum extraction and emergency caesarean section), as the intention was to study the use of instrumental deliveries rather than their success. Information about these outcomes was recorded at delivery in the obstetric record. Emergency caesarean section was defined as a caesarean section performed after the labor had started, either spontaneously or by induction.

Information about cohabitation status (living with the father-to-be or not), maternal height and body mass index (BMI) was collected at registration for antenatal care (usually at 8–12 weeks of gestation). BMI was calculated using maternal weight (kg), divided by maternal height squared ( $\text{m}^2$ ). BMI was categorized according to the World Health Organization as: underweight (BMI  $< 18.5 \text{ kg/m}^2$ ), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), mild obesity (BMI 30.0–34.9), severe obesity (BMI  $\geq 35.0$ ) (9). Information on induction of labor and use of epidural analgesia was recorded in the obstetric form during delivery, and information about maternal age, birthweight and head circumference was recorded after delivery. Length of

gestation was determined according to estimated due date based on routine ultrasound in the early second trimester. If this information was not available, the due date was based on last menstrual period. Individual information about mothers' country of birth was retrieved by cross-linking the Medical Birth Register to the Register of Total Population and Population Changes. Mothers' country of birth was stratified into Sweden, other Nordic countries (Denmark, Finland, Iceland and Norway), and non-Nordic countries. Information of years of completed formal education for mothers ( $\leq 9$ , 10–11, 12, 13–14 and  $\geq 15$  years) was retrieved from the nationwide Swedish Education Register.

Information on maternal diagnosis was based on the Swedish versions of the International Classification of Diseases, ninth (1992–1996) and tenth (1997–2010) revisions (ICD-9 and ICD-10, respectively). The following maternal diagnoses were included: pregestational diabetes (ICD-9 code 648A and ICD-10 codes O24.0–O24.3), gestational diabetes (ICD-9 code 648W and ICD-10 code O24.4) and pre-eclampsia (ICD-9 codes 642E, 642F and 642G and ICD-10 codes O14, O15.1 and O15.9). Vacuum extraction deliveries and emergency caesarean sections were, when possible, stratified into either prolonged labor [ICD-9 codes 661A, 661B and 661C and ICD-10 codes for labor dystocia (O62.0–O62.2) and prolonged labor (O63.0 and O63.1)] or fetal distress (ICD-9 code 656D and ICD-10 code O68). In the analyses of vacuum extractions by either prolonged labor or fetal distress, we excluded deliveries with both diagnoses to make the results clearer. From 1992 to 2010 the number of vacuum extractions due to prolonged labor, fetal distress, or a combination of the two diagnoses were 35 497, 24 009 and 9474, respectively.

## Statistical methods

First, we estimated associations between risk factors and risks of vacuum extraction and emergency caesarean section. We calculated odds ratios, using 95% confidence intervals, and adjusted for covariates included in Table 1. Thereafter, we estimated adjusted odds ratios for vacuum extraction based on the indications prolonged labor and fetal distress. All comparisons were made with spontaneous vaginal deliveries as the reference group.

Second, we studied the use of vacuum extraction over time. We calculated odds ratios of vacuum extraction in 2010 compared with 1992. To explain the increased risk of vacuum extraction over time, several models were performed. In regression model 1, we adjusted for maternal age, and in model 2 we also adjusted for induction of labor. In model 3, we added other maternal characteristics (maternal height, pre-eclampsia, pregestational diabetes and gestational diabetes). In model 4, we further

**Table 1.** Rates and adjusted OR of vacuum extraction and emergency cesarean section for primiparous women in Sweden 1992–2010 with spontaneous or induced onset of labor.

Variable	Number	Vacuum extraction ( <i>n</i> = 83 128)		Cesarean section ( <i>n</i> = 39 769)	
		%	Adjusted <sup>a</sup> OR (95% CI)	%	Adjusted <sup>a</sup> OR (95% CI)
Total	589 108	14.1		6.8	
Maternal age (years)					
≤24	169 913	10.2	0.68 (0.67–0.70)	4.3	0.61 (0.59–0.64)
25–29	224 503	13.8	1.00	6.0	1.00
30–34	145 881	17.1	1.32 (1.30–1.35)	8.5	1.57 (1.52–1.62)
35–39	40 934	20.3	1.72 (1.67–1.78)	13.0	2.48 (2.38–2.59)
≥40	6225	21.6	2.08 (1.93–2.25)	19.0	4.05 (3.72–4.40)
Missing	1652	13.4		7.9	
BMI first trimester					
≤18.4	16 333	13.0	1.09 (1.03–1.14)	3.4	0.78 (0.71–0.86)
18.5–24.9	347 622	14.0	1.00	5.5	1.00
25.0–29.9	106 056	15.2	1.04 (1.02–1.06)	9.0	1.43 (1.39–1.47)
30.0–34.9	27 731	14.1	0.96 (0.93–1.00)	12.3	1.89 (1.81–1.98)
35.0–39.9	7467	13.7	0.93 (0.86–1.00)	15.6	2.29 (2.13–2.47)
≥40.0	2268	14.8	1.03 (0.90–1.17)	18.3	2.52 (2.21–2.86)
Missing	83 899	14.3		7.6	
Maternal height (cm)					
≤155	21 376	16.2	1.91 (1.82–2.00)	14.6	5.08 (4.81–5.35)
156–165	218 737	15.0	1.37 (1.34–1.39)	7.9	1.99 (1.93–2.04)
166–175	261 742	13.0	1.00	4.9	1.00
≥176	39 567	11.5	0.76 (0.74–0.79)	3.3	0.54 (0.50–0.57)
Missing	47 686	18.3		10.4	
Country of origin					
Sweden	481 739	14.2	1.00	6.6	1.00
Other Nordic country	10 965	14.6	0.94 (0.88–1.00)	7.4	1.05 (0.96–1.15)
Non-Nordic	85 095	14.1	0.98 (0.96–1.01)	7.6	0.99 (0.96–1.03)
Missing	11 309	8.5		4.8	
Living with partner					
Yes	512 588	14.3	1.00	6.8	1.00
No	40 829	12.0	0.89 (0.85–0.92)	6.3	0.98 (0.93–1.03)
Missing	35 691	13.8		7.2	
Diabetes					
Gestational diabetes	4027	15.7	1.05 (0.95–1.16)	13.7	1.16 (1.04–1.31)
Pregestational	1799	23.7	2.48 (2.16–2.86)	31.0	4.44 (3.85–5.12)
No	583 282	14.1	1.00	6.6	1.00
Pre-eclampsia					
Yes	20 225	16.1	1.18 (1.13–1.24)	17.9	1.60 (1.52–1.68)
No	568 883	14.0	1.00	6.4	1.00
Length of gestation (weeks)					
37–38	103 491	10.6	0.86 (0.84–0.88)	5.4	0.89 (0.86–0.92)
39–40	346 852	13.3	1.00	5.5	1.00
41	136 519	17.4	1.24 (1.21–1.26)	9.4	1.61 (1.56–1.66)
Sex of the baby					
Male	298 668	15.5	1.15 (1.13–1.18)	7.4	1.16 (1.13–1.19)
Female	290 416	12.6	1.00	6.1	1.00
Birthweight (g)					
≤2999	76 225	11.6	1.13 (1.09–1.16)	6.9	1.28 (1.23–1.33)
3000–3999	431 309	13.5	1.00	5.3	1.00
≥4000	78 270	17.7	1.14 (1.11–1.17)	11.9	2.28 (2.20–2.35)
Head circumference (cm)					
≤34	243 898	10.2	0.78 (0.76–0.79)	5.1	0.82 (0.79–0.84)
35	152 411	13.0	1.00	6.2	1.00
≥36	168 680	19.5	1.53 (1.49–1.56)	8.2	1.12 (1.08–1.16)

**Table 1.** Continued

Variable	Number	Vacuum extraction ( <i>n</i> = 83 128)		Caesarean section ( <i>n</i> = 39 769)	
		%	Adjusted <sup>a</sup> OR (95% CI)	%	Adjusted <sup>a</sup> OR (95% CI)
Induction of labor					
Yes	49 687	16.7	1.23 (1.19–1.27)	19.3	3.30 (3.19–3.41)
No	537 175	13.5	1.00	5.2	1.00
Year of birth					
1992–1997	184 700	12.3	1.00	5.2	1.00
1998–2004	192 010	14.1	1.00 (0.98–1.03)	6.6	1.05 (1.01–1.08)
2005–2010	210 152	14.8	1.04 (1.01–1.06)	7.3	1.07 (1.04–1.11)
Epidural					
Yes	252 136	20.0	2.20 (2.16–2.24)	9.6	1.97 (1.92–2.02)
No	336 972	9.7	1.00	4.6	1.00

CI, confidence interval; OR, odds ratios; BMI, body mass index.

<sup>a</sup>OR are adjusted for effects of the other variables included in the table.

adjusted for infant characteristics (weight and head circumference at birth).

The use of epidural analgesia has previously been shown to be associated with vacuum extraction (10). Due to the complexity of the effect of epidural analgesia on progress of labor and differences in methods of epidural analgesia over time, we investigated interactions between use of epidural analgesia (yes/no) and year of birth (continuous) and risk of vacuum extraction in a multivariate model.

The statistical software package SPSS 20.0 (SPSS Inc., Chicago, IL) was used for all data analyses. The study was approved by the Research Ethics Committee at Karolinska Institute, Stockholm (no. 2008/1322-31).

## Results

In our cohort of singleton term pregnancies with spontaneous or induced onset of labor (*n* = 589 108), overall rates of vacuum extraction and emergency caesarean section were 14.1% (*n* = 83 128) and 6.8% (*n* = 39 769), respectively.

The risks of both vacuum extraction and emergency caesarean section increased with maternal age and gestational length, but decreased with increasing maternal height (Table 1). BMI did not substantially influence risk of vacuum extraction, but was strongly and positively associated with risk of emergency caesarean section. Compared with nondiabetic women, women with pregestational diabetes faced more than a twofold increased risk of vacuum extraction and a fourfold increased risk of emergency caesarean section. Women with induced onset of labor had a slightly increased risk of vacuum extraction and a more than threefold increased risk of caesarean section. Mothers of infants with large head circumferences ( $\geq 36$  cm) had an increased risk of vacuum extraction and

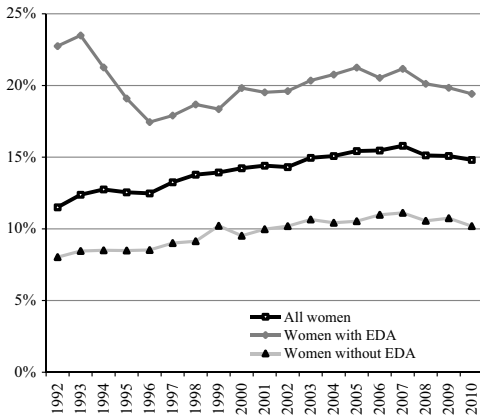
also a slightly increased risk of emergency caesarean section. Women using epidural analgesia had a 120% and a 100% increase in risks of vacuum extractions and emergency caesarean sections, respectively. Maternal level of education was not associated with risks of vacuum extraction or emergency caesarean section (data not shown).

As maternal age and height had high impact on the probability of vacuum extraction and caesarean section, it is noteworthy that these two variables alone alter the absolute risk of vacuum extraction from as few as 1 in 14 pregnancies (among women aged <25 years with a height of at least 176 cm) to 1 in 5 pregnancies (among women aged  $\geq 40$  years with a height of 155 cm or less). The probability of emergency caesarean section ranged, by similar combinations of maternal age and height, from 1 in 43 pregnancies to 1 in 8 pregnancies, respectively.

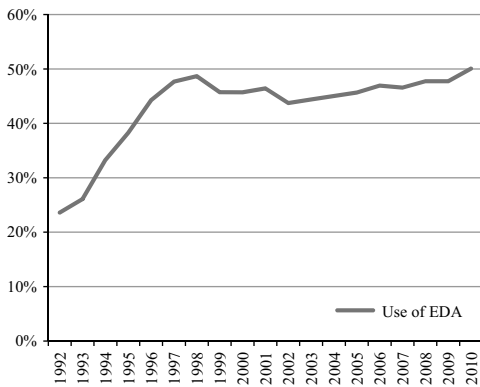
In stratified analyses, we next investigated risk factors for vacuum extraction among women with indications of prolonged labor or fetal distress. The results were similar to those presented in Table 1, and showed that factors that contributed to an increased risk of vacuum extraction due to prolonged labor also contributed to an increased risk of vacuum extraction due to fetal distress (data not shown).

The second aim of this study was to investigate the increase in vacuum extraction over time and if changes in prevalence of risk factors could explain the increase in vacuum extraction rates (from 11.5% in 1992 to 14.8% in 2010, Figure 1). Among women not using epidural analgesia, the rate of vacuum extractions increased from 8.0% in 1992 to 10.2% in 2010 (Figure 1). Among women using epidural analgesia, the rate of vacuum extraction decreased from 22.8% to 17.9% during 1992–1997. After this sudden drop, the frequency increased to peak in 2005 (21.3%), before decreasing to 19.4% in 2010. From 1992 to 1997, the prevalence of epidural analgesia increased

markedly in Sweden (Figure 2). During this period, sufentanil, the so called “stand-up” epidural, was introduced in Sweden (11).



**Figure 1.** Rates of vacuum extraction among all primiparous women, women with epidural analgesia (EDA) and women without epidural analgesia from 1992 to 2010.



**Figure 2.** Rate of epidural analgesia (EDA) among primiparous women in Sweden 1992 to 2010.

Risk factors for vacuum extraction that increased in prevalence between 1992 and 2010 were high maternal age (30–34 years, from 15.5 to 27.7% and  $\geq 35$  years, from 4.5 to 10.8%), induction of labor (from 5.5 to 11.4%), and a large ( $\geq 36$  cm) infant head circumference (from 26.0 to 31.5%). We found a significant interaction between epidural analgesia use over time and risk of vacuum extraction ( $p < 0.001$ ). Analyses of time trends of vacuum extraction were therefore stratified by epidural analgesia (yes/no).

Among women with no epidural analgesia, there was a 39% increase in the odds of vacuum extraction in 2010 compared with 1992 in the crude analysis (Table 2). When we adjusted for maternal age, this risk was reduced to a 24% increase in risk (model 1). Further adjustments for induction of labor (model 2), other maternal characteristics (model 3) and infant characteristics (model 4) did not attenuate this risk additionally. Hence, we were unable to explain a large fraction of the increase in vacuum extraction over time among women without epidural analgesia. Among women with epidural analgesia, there was no time effect in the crude analysis, but after adjusting for maternal age, there was a slightly reduced risk of vacuum extraction in 2010 compared with 1992 (Table 2).

Because of the introduction of a new epidural anesthesia drug (sufentanil), which probably led to both a markedly increased use of epidural analgesia and, among women with epidural analgesia, to a reduced risk of vacuum extraction, we conducted additional analyses limited to the years 1997–2010 (Table 3). In women with no epidural anesthesia, there was a 22% increased risk of vacuum extraction in 2010 compared with 1997. After adjusting for maternal age, this risk was reduced to a 13% increase in risk, and further adjustments did not substantially influence this risk. In women with epidural anesthesia, there was also a 13% increased risk of vacuum extraction in 2010 compared with 1997. After adjusting for maternal age, induction of labor and other maternal characteristics, this risk was no longer significantly increased.

Finally, we investigated time trends of vacuum extractions among women with fetal distress or prolonged labor

**Table 2.** OR and 95% CI for vacuum extraction 2010 versus 1992<sup>a</sup> among primiparous women in Sweden. Analyses are stratified for use of EDA.

	Crude	Model 1	Model 2	Model 3	Model 4
Women without EDA	1.39 (1.33–1.44)	1.24 (1.20–1.29)	1.24 (1.20–1.29)	1.25 (1.20–1.30)	1.24 (1.19–1.29)
Women with EDA	0.98 (0.94–1.01)	0.86 (0.83–0.89)	0.86 (0.83–0.89)	0.85 (0.82–0.87)	0.85 (0.81–0.88)

OR, odds ratios; CI, confidence intervals; EDA, epidural analgesia.

Model 1: adjusted for maternal age; Model 2: adjusted for maternal age + induction of labor; Model 3: adjusted for all of above + height + pre-eclampsia + pregestational diabetes + gestational diabetes; Model 4: adjusted for all of above + birthweight + head circumference.

<sup>a</sup>Reference group.

**Table 3.** OR and 95% CI for vacuum extraction in 2010 versus 1997<sup>a</sup> among primiparous women in Sweden. Analyses are stratified by use of EDA and indication of vacuum extraction.

	Crude	Model 1	Model 2	Model 3	Model 4
No EDA					
All women	1.22 (1.14–1.30)	1.13 (1.06–1.21)	1.13 (1.06–1.21)	1.16 (1.08–1.24)	1.17 (1.09–1.26)
Due to FD	1.80 (1.70–1.92)	1.69 (1.59–1.80)	1.68 (1.59–1.79)	1.66 (1.56–1.77)	1.62 (1.52–1.73)
Due to PL	1.04 (0.98–1.11)	0.91 (0.85–0.96)	0.91 (0.86–0.97)	0.92 (0.86–0.98)	0.92 (0.87–0.99)
EDA					
All women	1.13 (1.08–1.19)	1.03 (0.98–1.09)	1.03 (0.97–1.08)	1.01 (0.96–1.07)	1.01 (0.95–1.07)
Due to FD	1.58 (1.48–1.68)	1.44 (1.35–1.54)	1.42 (1.33–1.52)	1.42 (1.32–1.52)	1.41 (1.31–1.51)
Due to PL	0.82 (0.78–0.86)	0.73 (0.70–0.77)	0.74 (0.70–0.77)	0.73 (0.70–0.77)	0.73 (0.69–0.77)

OR, odds ratios; CI, confidence intervals; EDA, epidural analgesia; FD, fetal distress; PL, prolonged labor.

Model 1: adjusted for maternal age; Model 2: adjusted for all of above + induction of labor; Model 3: adjusted for all of above + height + pre-eclampsia + pregestational diabetes + gestational diabetes; Model 4: adjusted for all of above + birthweight + head circumference.

<sup>a</sup>Reference group.

(Table 3). The single largest increase in risk was among women without epidural analgesia and vacuum extraction due to fetal distress (80%), a risk which remained largely unexplained after adjustments.

## Discussion

In our nationwide study of Swedish primiparous women, there was a 40% increase in risks of vacuum extraction from 1992 to 2010, which was mainly explained by increasing maternal age and increased use of epidural analgesia. However, a substantial fraction of the increase in vacuum extraction use among women without epidural analgesia remains to be explained.

Due to increasing maternal age in Sweden (1) and in other western countries (12,13), extended research has focused on older age as a risk factor for adverse labor outcomes, such as labor dystocia (14), asphyxia (15) and increased rates of unplanned cesarean section (14,16,17). Results in a recently published systematic review illustrate that the relative risk of cesarean delivery among older ( $\geq 35$  years) women compared with younger women ranges from a 40% increase to a 2.8-fold increase in risk (18). Along with epidural analgesia, maternal age was the variable in this study that explained a large fraction of the increased use of vacuum extractions in Sweden between 1992 and 2010.

There has been a large increase in use of epidural anesthesia since 1992. The increased availability of epidural analgesia and the favorable experiences of women who have had close to painless labor with epidural block have altered the expectations of pregnant women entering labor. A Cochrane review suggested that epidural use may be associated with malposition of the fetal head, prolonged labor, and increased use of oxytocin and of instrumental deliveries (10). The findings were incongruent as

to whether epidural analgesia increases the risk of cesarean section (10).

The results showing no association between obesity and vacuum extraction but a strong association between increasing BMI and cesarean section could partly be explained by the finding that labor dysfunction in obese women predominantly occurs in the first stage (19). The mechanisms are not fully understood, but there may be a dose-dependent reduction in uterine contractility with increasing BMI (20). Reduced uterine contractility leads to prolonged labor before full cervical dilatation is achieved, thereby contraindicating vacuum extraction. Obese women who reach the second stage of labor are unlikely to have compromised expulsive efforts as intrauterine pressure during active pushing has been reported to be the same between BMI groups (21). Hence, obese women may be less likely to reach the second stage of labor, but obese women who reach the second stage are just as likely as other women to have a noninstrumental delivery.

Short women have previously been reported to have increased risks of labor dystocia (22,23), fetal distress during labor (24) and increased risks of unplanned cesarean deliveries (17,22,23,25). However, large studies have shown contradicting results for the association between short stature and the rate of vacuum extraction. In a population-based Israeli study, a short maternal stature reduced the risk of vacuum extraction but increased the risk of unplanned cesarean section associated with failure to progress in the second stage of labor (23). In contrast, Kelly *et al.* reported in a meta-analysis a highly significant correlation between short stature and instrumental vaginal delivery, including delivery by forceps or by vacuum extraction (26). Short maternal stature is associated with second stage dystocia (23), and there are regional and international differences in obstetric management of dystocia in the second stage of labor. In

Sweden, the standard of care for dystocia in the second stage is to attempt a delivery by vacuum extraction, and a cesarean section is usually considered the second choice.

In congruence with another study (27), we found that the indication of fetal distress is used more liberally today than in 1997. This applies both to women with and without epidural anesthesia. It is unclear if fetuses in fact are more distressed today than in 1997, or if they are perceived to be more distressed. Perhaps more frequent use of oxytocin augmentation (28), fetal monitoring and more liberal use of fetal blood sampling contribute to the increased use of fetal distress as an indication (29). Oxytocin augmentation has previously been associated with both instrumental deliveries and Apgar <7 at 5 min (28). Unfortunately, information about oxytocin use was not available in our data set.

Strengths of our study include the size of this population-based study, which makes chance an unlikely explanation for our findings. Information on the factors studied was recorded before delivery, which precludes bias in reporting by mode of delivery. The ICD-10 diagnoses of *prolonged labor* and *fetal distress* that were used for information on indications have not been validated and some patients may have been misdiagnosed.

In conclusion, depending on the factors described in this study, the risks of a delivery by vacuum extraction can vary immensely from one woman to another. It is of clinical importance to be aware of these differences in order to give proper care and information to each individual woman and her partner before and during the delivery process. The increase of vacuum extractions over the last decades is to a large extent explained by increasing maternal age and increased use of epidural analgesia. However, other unidentified maternal and infant characteristics may also contribute to the increase in vacuum extractions over time. The increase in deliveries by vacuum extraction is mainly due to fetal distress in women with or without epidural analgesia.

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AOGS MAIN RESEARCH ARTICLE

# The influence of fetal head circumference on labor outcome: a population-based register study

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## Key words:

Head circumference, prolonged labor, dystocia, fetal distress, maternal distress, vacuum extraction, emergency cesarean section

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## Conflict of interest

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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## Abstract

**Objective.** To investigate the association between postnatal head circumference and the occurrence of the three main indications for instrumental delivery, namely prolonged labor, signs of fetal distress and maternal distress. We also studied the association between postnatal fetal head circumference and the use of vacuum extraction and emergency cesarean section. **Design.** Population-based register study. **Setting.** Nationwide study in Sweden. **Population.** A total of 265 456 singleton neonates born to nulliparous women at term between 1999 and 2008 in Sweden. **Methods.** Register study with data from the Swedish Medical Birth Register. **Main outcome measures.** Prolonged labor, signs of fetal distress, maternal distress, use of vacuum extraction and emergency cesarean section. **Results.** The prevalence of each outcome increased gradually as the head circumference increased. Compared with women giving birth to a neonate with average size head circumference (35 cm), women giving birth to an infant with a very large head circumference (39–41 cm) had significantly higher odds of being diagnosed with prolonged labor [odds ratio (OR) 1.49, 95% confidence interval (CI) 1.33–1.67], signs of fetal distress (OR 1.73, 95% CI 1.49–2.03) and maternal distress (OR 2.40, 95% CI 1.96–2.95). The odds ratios for vacuum extraction and cesarean section were thereby elevated to 3.47 (95% CI 3.10–3.88) and 1.22 (95% CI 1.04–1.42), respectively. The attributable risk proportion percentages associated with vacuum extraction and cesarean section were 46 and 39%, respectively among the cases exposed to a head circumference of 37–41 cm. **Conclusions.** Large fetal head circumference is associated with complicated labor and is etiological to a considerable proportion of assisted vaginal births and emergency cesarean sections.

**Abbreviations:** BMI, body mass index; CI, confidence interval; EDA, epidural analgesia; ICD, International Classification of Diseases; OR, odds ratio.

## Introduction

Prolonged labor is the major cause of asphyxia in term-born neonates (1) and can be due to inefficient uterine action, malpresentation and cephalopelvic disproportion (2). Active management of labor is well recognized as the primary policy to prevent and treat prolonged labor, while assisted vaginal delivery and emergency cesarean are left for the unresolved abnormal labors.

High birthweight increases the risk of prolonged labor (3–5), use of epidural analgesia (EDA; 6) and instrumen-

tal or operative delivery (5,7–9). Better understanding of the impact of maternal and infant anthropometric measures on the course of labor may enhance the possibilities of appropriate timing of assistance to have a safe and undramatic birth. As ultrasonographic estimation of macrosomia is not always accurate (10), there is a need to develop other methods to foresee this factor. A clinical study ( $n=423$ ) suggests that measuring fetal head circumference ( $>37$  cm) is as good as fetal weight estimate ( $>4.5$  kg) to predict prolonged labor (11). Large and prospective studies are requested to confirm this for clinical management guidelines. However, few

studies have investigated the association of infant head circumference on the risk for prolonged labor, signs of fetal distress and instrumental delivery.

Using total-population-based observational data for the Swedish birth cohorts from 1998 to 2008, the first aim of this study was to investigate the association between postnatal fetal head circumference and the prevalence of three main indications for instrumental and operative delivery, namely prolonged labor, signs of fetal distress and maternal distress. The second aim was to investigate the association of postnatal fetal head circumference with the risk for vacuum extraction and emergency cesarean section.

## Material and methods

This was a population-based study on data from the Swedish Medical Birth Register, held by the National Board of Health and Welfare. The register covers 99% of all births in Sweden and is based on medical records from all antenatal care clinics, delivery and neonatal care units. Starting with the first antenatal visit, which usually occurs in the first trimester, information is collected prospectively for all pregnancies and births, including medical history, methods of pain relief during delivery, mode of delivery and vital information regarding the newborn infant.

The study population included all singleton neonates born to nulliparous women at term between 1999 and 2008 in Sweden ( $n=359\,184$ ). Term indicates a gestational age of  $\geq 37$  or  $<42$  completed weeks and was determined by routine ultrasound in the second trimester. Only nulliparous women were studied to increase homogeneity and to exclude the possibility that a previous complicated birth could have influenced the course of labor. Deliveries not in cephalic presentation were excluded, as were all deliveries with missing information on the study variables. The population was also limited to those with head circumference 28–41 cm and birthweight  $\geq 2500$  g to avoid unrealistic measurements and possible outliers. Unsuccessful vacuum extractions leading to cesarean sections ( $n=815$ ) were accounted for in both outcomes. A total of 265 456 deliveries met the inclusion criteria.

In the Medical Birth Register, maternal age at childbirth and maternal weight and height were identified. Data on the birthweight (in grams), neonatal head circumference (in centimeters) of the infant and the gestational age (in completed gestational weeks) were also collected. Infant head circumference and birthweight were routinely measured by a midwife within three hours after birth. Maternal weight and height were recorded in early pregnancy. Body mass index (BMI) was calculated using the maternal weight in the first trimester and categorized as follows, according to the World Health Organization's standards: underweight (BMI less than 18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight

(25–29.9 kg/m<sup>2</sup>), obesity (30–34.9 kg/m<sup>2</sup>) and severe obesity (35 kg/m<sup>2</sup> or higher).

We studied the following primary outcomes: (diagnosis of) prolonged labor, signs of fetal distress and maternal distress. The secondary outcomes were vacuum extraction and emergency cesarean section. Diagnoses were classified according to the Swedish version of the International Classification of Diseases (ICD). The diagnosis 'prolonged labor' was defined by the ICD-10 codes for labor dystocia (O62.0, O62.1, O62.2, O62.8 and O62.9) and prolonged labor (O63.0, O63.1 and O63.9). The diagnosis 'maternal distress' was defined by O75.0 and 'fetal distress' by the ICD-10 O68. The ICD code used to define the diagnosis 'fetal distress' is based on signs of stress during the delivery (such as fetal heart rate anomalies, biochemical evidence of fetal distress and/or meconium in the amniotic fluid) and not the actual status of the newborn. Therefore, the diagnosis is not an indication of how many infants actually suffered from asphyxia at birth. In Sweden, the obstetrician performing the vacuum extraction or cesarean section is supposed to register the main indication for the operation; however, sometimes more than one diagnosis was used for the same patient, causing an overlap presented in the Results section.

## Statistical analysis

Descriptive statistics for continuous variables were presented as means and standard deviations. Multivariate analysis was conducted by logistic regression to estimate adjusted odds ratios (ORs) for prolonged labor, signs of fetal distress, maternal distress, vacuum extraction and emergency cesarean section with 95% confidence intervals (CIs). Births in which the infant had the most prevalent head circumference (35 cm) were used as the reference group. In the first regression models, we adjusted for year of birth as a continuous variable to control for fluctuations in outcomes. In the second model, birthweight was added and in the third, maternal height, BMI, age and use of epidural analgesia were included. Fetal distress and maternal distress were additionally adjusted for prolonged labor. The secondary outcomes (vacuum extraction and emergency cesarean section) were adjusted for year of birth, birthweight, maternal height, BMI, age and EDA.

In order to study if the association between head circumference and the outcomes varies by birthweight, stratified analyses were performed and presented as figures. Infants with a birthweight  $<3000$  and  $>4000$  g were then analysed separately. If an outcome did not occur in more than 15 infants with a certain head circumference, the group was not included in the presentation. Also we decided to exclude the outcome 'maternal distress' in these figures owing to a low proportion with this diagnosis.

Adjustments were made for age in four groups ( $<25$ , 25–29, 30–34 and 35+ years), height in three groups ( $<160$ ,

160–169 and 170+ cm), first-trimester BMI in four groups (<18.5, 18.5–24.9, 25–29.9 and 30+ kg/m<sup>2</sup>) and birthweight in five groups (<3000, 3000–3499, 3500–3999, 4000–4499 and >4500 g). A descriptive analysis was performed on the association between fetal birthweight and the primary and secondary outcomes. Attributable risk proportion and population attributable risk were calculated for the secondary outcomes (12).

The statistical software package IBM SPSS 19.0 (SPSS Inc., Chicago, IL, USA) was used for all data analyses.

The study was approved by the ethical committee of the Karolinska Institute.

## Results

A total of 21% of the women were diagnosed with prolonged labor, 11% with signs of fetal distress and 3% with maternal distress. Fifteen per cent of all deliveries were vacuum extractions and 7% emergency cesarean sections. The mean head circumference in the cohort was 34.8±1.4 cm, median 35.0 cm.

Of the 38 853 women who delivered by vacuum extraction and the 18 946 women who delivered by emergency cesarean sections, 36 527 (94%) and 15 285 (81%), respectively, were diagnosed with prolonged labor, signs of fetal distress, maternal distress or a combination of these diagnoses. Approximately 20% of the vacuum extractions and 12% of the emergency cesarean sections had two indications documented.

Table 1 shows the maternal and fetal anthropometric characteristics of the population in relation to the fetal head circumference. The mean maternal age, maternal height, BMI and birthweight increased as fetal head circumference increased.

Table 2 shows the association between head circumference and the primary and secondary outcomes. The prevalence of each diagnosis increased gradually as the fetal head circumference increased. For instance, the proportion with

women diagnosed with prolonged labor increased from 14% among those with infants with the smallest head circumference (28–32 cm) to 38% among those with the largest (39–41 cm) and the proportion with women having a vacuum extraction increased from 9% (circumference 28–32 cm) to 35% (39–41 cm).

Tables 3–5 show ORs for the primary outcomes in relation to fetal head circumference. The odds for all three outcomes increased gradually with increasing head circumference (model 1; Tables 3–5).

After adjustment for year of birth, the OR of being diagnosed with prolonged labor was 2.33 among those with offspring with head circumference of 39–41 cm. Birthweight explained some of the increased risk and after adjusting for this factor the OR decreased to 1.56. When the analysis was further adjusted for maternal age, BMI, height and EDA, the risk was only slightly attenuated and still statistically significant. In contrast to prolonged labor, the OR for signs of fetal distress increased for the same group from 1.30 to 1.87 when adjusted for birthweight. When further adjusted for other potential confounders, the OR then decreased slightly. However, it should be mentioned that only a fraction, 3.9%, of the infants diagnosed with fetal distress also suffered from asphyxia, defined as Apgar score <7 at five minutes of age. Among those diagnosed with prolonged labor or maternal distress, the corresponding proportion was 1.6%.

Table 6 shows the adjusted odds ratios for vacuum extraction and emergency cesarean. After adjustments for trends in time, birthweight, maternal height, BMI, age and use of epidural analgesia, increased odds for both vacuum extraction and emergency cesarean section remained for those with a head circumference larger than 35 cm. In fact, those infants with head circumference 39–41 cm had 3.5 times higher odds of being delivered by vacuum extraction compared with the reference group. The odds ratio for emergency cesarean section among those with a head circumference 39–41 cm was 1.22, indicating a statistically significant increased prevalence compared with the reference group, but not as clear as for

**Table 1.** Descriptives of population in relation to infant head circumference.

Head circumference (cm)	Distribution		Maternal age (years) Mean±SD	Maternal height (cm) Mean±SD	Maternal body mass index (kg/m <sup>2</sup> ) Mean±SD	Birthweight (g) Mean±SD
	<i>n</i>	%				
28–32	12056	4.5	27.6±5.0	163.9±6.2	23.4±4.0	3004±299
33	32321	12.2	27.6±5.0	165.2±6.1	23.5±3.9	3179±331
34	64003	24.1	27.8±4.9	166.1±6.2	23.6±4.0	3348±348
35	73078	27.5	28.0±4.9	166.9±6.2	23.9±4.1	3528±357
36	53240	20.1	28.1±4.9	167.5±6.2	24.1±4.2	3724±367
37	22981	8.7	28.3±4.9	168.2±6.3	24.6±4.4	3932±388
38	6248	2.4	28.4±4.9	168.7±6.2	25.0±4.7	4132±417
39–41	1529	0.6	28.3±4.9	168.8±6.2	25.5±4.9	4278±512
Total	265456	100%	27.9±4.9	166.7±6.3	23.9±4.1	3511±442

**Table 2.** Proportion of prolonged labor, fetal distress, maternal exhaustion, vacuum extraction and emergency cesarean section in relation to fetal head circumference.

Head circumference (cm)	Prolonged labor		Fetal distress		Maternal exhaustion		Vacuum extraction		Cesarean section	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
28–32	1732	14.4	1154	9.6	156	1.3	1125	9.3	568	4.7
33	4980	15.4	3143	9.7	592	1.8	3413	10.6	1686	5.2
34	11 242	17.6	6281	9.8	1252	2.0	7288	11.4	3760	5.9
35	15 273	20.9	7620	10.4	1797	2.5	10 022	13.7	5113	7.0
36	13 527	25.4	5917	11.1	1847	3.5	9445	17.7	4480	8.4
37	7186	31.3	2685	11.7	1117	4.9	5243	22.8	2370	10.3
38	2322	37.2	778	12.5	366	5.9	1781	28.5	757	12.1
39–41	583	38.1	201	13.1	116	7.6	536	35.1	212	13.9
Total	56 845	21.4	27 779	10.5	7243	2.7	38 853	14.6	18 946	5.4

**Table 3.** Logistic regression on the association between head circumference and prolonged labor.

Head circumference (cm)	Model 1		Model 2		Model 3	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
28–34	0.75	0.73–0.77	0.87	0.85–0.90	0.89	0.87–0.91
35	1.0		1.0		1.0	
36	1.29	1.26–1.33	1.16	1.12–1.19	1.13	1.09–1.16
37	1.73	1.67–1.79	1.38	1.33–1.42	1.30	1.26–1.35
38	2.25	2.13–2.38	1.61	1.52–1.70	1.52	1.44–1.62
39–41	2.33	2.10–2.59	1.56	1.40–1.73	1.49	1.33–1.67

Model 1 was adjusted for year. Model 2 was adjusted for year and birthweight. Model 3 was adjusted for year, birthweight, maternal height, body mass index, age and epidural analgesia.

**Table 4.** Logistic regression of the association between head circumference and complicated labor due to signs of fetal distress.

Head circumference (cm)	Model 1		Model 2		Model 3	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
28–34	0.93	0.90–0.96	0.81	0.78–0.84	0.82	0.80
35	1		1		1	
36	1.07	1.04–1.11	1.19	1.15–1.23	1.16	1.12–1.20
37	1.14	1.08–1.19	1.40	1.33–1.47	1.32	1.26–1.39
38	1.22	1.13–1.32	1.66	1.53–1.80	1.53	1.41–1.66
39–41	1.30	1.12–1.51	1.87	1.60–2.17	1.73	1.49–2.03

Model 1 was adjusted for year. Model 2 was adjusted for year and birthweight. Model 3 was adjusted for year, birthweight, maternal height, body mass index, age, epidural analgesia and prolonged labor.

**Table 5.** Logistic regression of the association between head circumference and maternal distress

Head circumference (cm)	Model 1		Model 2		Model 3	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
28–34	0.75	0.70–0.80	0.80	0.75–0.85	0.83	0.77–0.88
35	1		1		1	
36	1.43	1.33–1.52	1.36	1.27–1.45	1.30	1.21–1.39
37	2.03	1.88–2.19	1.83	1.69–1.98	1.67	1.54–1.81
38	2.47	2.20–2.77	2.13	1.88–2.40	1.86	1.65–2.11
39–41	3.26	2.68–3.96	2.72	2.22–3.32	2.40	1.96–2.95

Model 1 was adjusted for year. Model 2 was adjusted for year and birthweight. Model 3 was adjusted for year, birthweight, maternal height, body mass index, age, epidural analgesia and prolonged labor.

**Table 6.** Logistic regression of the association between head circumference on vacuum extraction and emergency cesarean section.

Head circumference (cm)	Vacuum extraction*		Emergency cesarean section*	
	Odds ratio	95% Confidence interval	Odds ratio	95% Confidence interval
28–34	0.78	0.75–0.80	0.93	0.89–0.97
35	1		1	
36	1.34	1.30–1.39	1.05	1.00–1.10
37	1.82	1.75–1.90	1.11	1.05–1.17
38	2.49	2.33–2.65	1.14	1.04–1.24
39–41	3.47	3.10–3.88	1.22	1.04–1.42

\*Adjusted for year, birthweight, maternal height, body mass index, age and epidural analgesia.

vacuum extraction. In other words, a large head circumference increased the odds for vacuum extraction more than the odds for emergency cesarean section. The results of attributable risk proportions showed that 46% of the vacuum extractions and 39% of the cesarean sections in the group with head circumference 37–41 cm could be related to the large head circumference compared with a 9 and 7% attributable risk in the population.

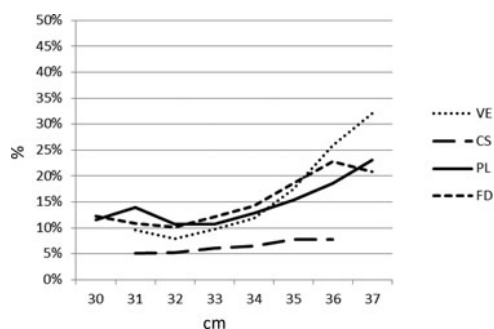
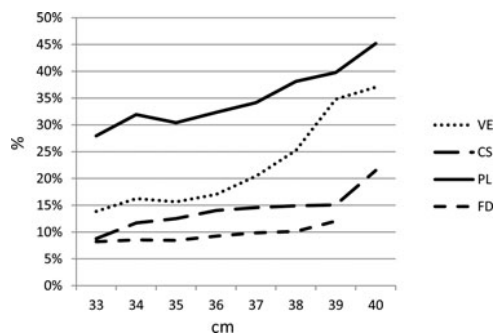
Figures 1 and 2 show stratified analyses for infants with a birthweight  $\leq 3000$  and  $\geq 4000$  g. The relation between increasing head circumference and the outcomes were similar in the two groups; however, signs of fetal distress increased more rapidly in relation to head circumference when the infant birthweight was  $\leq 3000$  g compared with  $\geq 4000$  g.

## Discussion

Our results showed that the odds of prolonged labor, fetal distress, maternal distress, vacuum extraction and emergency cesarean gradually increased as fetal head circumference increased. High birthweight explained some of the likelihood for prolonged labor and maternal distress, but not the increased odds for fetal distress. The proportion with spontaneous vaginal delivery was only 59% for women with infants with head circumferences of 38–41 cm compared with 80% for those with head circumference of 35 cm (not shown in the tables).

The attributable risk proportions of large head circumference for assisted vaginal delivery and abdominal delivery indicate the importance of considering cephalopelvic disproportion in modern obstetrics.

Clinical studies have addressed macrosomia as a risk factor for dystocic labor and non-spontaneous delivery (5,8). Our findings indicating that a large head circumference increases the risk for prolonged labor are supported by Kennelly *et al.* (11), who reported that a fetal head circumference of 37 cm or more was associated with significantly prolonged first and

**Figure 1.** Proportion of the primary and secondary outcomes in relation to fetal head circumference (in centimeters) in low-birthweight infants ( $<3000$  g,  $n=32\,758$ ).**Figure 2.** Proportion of the primary and secondary outcomes in relation to fetal head circumference (in centimeters) in high-birthweight infants ( $>4000$  g,  $n=36\,116$ ).

second stages of labor. For obstetric reasoning, a purportedly strict division of dystocia/prolonged labor into inefficient uterine action, occipito-posterior position and cephalopelvic disproportion might not be fully appropriate because inefficient uterine action is also a consequence of cephalopelvic disproportion.

Although the fetal head should be of primary importance during the passage through the birth canal, macrosomia might also be as important in hampering efficient uterine contractions for the nullipara. The correlation between both head circumference and birthweight and dystocic outcomes might be almost linear, as indicated in this study. These clear-cut associations are in contrast to earlier, smaller clinical studies (5,7) showing a more complex pattern between the triad of head circumference, birthweight and outcomes than was confirmed in this large prospective study. Thus, the results of the present study are original because they give a clear picture of the degree of the impact that head circumference has on major adverse labor outcomes. Even in the fully

adjusted models, including birthweight, statistically significant associations between a large head circumference and the outcomes remained.

One could argue that prolonged labor itself is a causal factor for fetal distress, but it is noteworthy that the results in this study indicated that a large head circumference is an independent risk factor for fetal distress. The reason for this is unclear, because we were unable to find any other studies reporting this finding; however, one could speculate that a much increased pressure on the fetal skull and pronounced moulding is more common among those with a large head circumference than among those with a smaller circumference, which in turn could contribute to signs of fetal distress.

The major strengths of this study are the large study population and the prospective collection of data, minimizing the risk of selection and recall bias. Based on the design, we were able to adjust for a number of confounding and mediating factors. The exposure variable, fetal head circumference, is certainly valid because it is easy to measure and routinely recorded by midwives after the delivery. In contrast, the ascertainment of the primary outcome variables (prolonged labor, signs of fetal distress and maternal distress) may be more difficult because they are based on a number of clinical observations. Therefore, we cannot rule out the possibility that some diagnoses were inaccurate. However, since our study population was very large, there was a limited risk that misclassification of diagnoses biased our results in a substantial manner.

In conclusion, this study shows that fetal head circumference plays a major role in the labor process and that a fetal head circumference of 37–41 cm is etiological to almost half of the assisted vaginal births and one-third of the emergency cesarean operations. This may prompt the development of new predictive methods for measuring fetal size for early diagnosis and appropriate management.

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III



# Birth Experience in Women with Low, Intermediate or High Levels of Fear: Findings from the First Baby Study

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**ABSTRACT: Background:** Fear of childbirth and mode of delivery are two known factors that affect birth experience. The interactions between these two factors are unknown. The aim of this study was to estimate the effects of different levels of fear of birth and mode of delivery on birth experience 1 month after birth. **Methods:** As part of an ongoing prospective study, we interviewed 3,006 women in their third trimester and 1 month after first childbirth to assess fear of birth and birth experience. Logistic regression was performed to examine the interactions and associations between fear of birth, mode of delivery and birth experience. **Results:** Compared with women with low levels of fear of birth, women with intermediate levels of fear, and women with high levels of fear had a more negative birth experience and were more affected by an unplanned cesarean section or instrumental vaginal delivery. Compared with women with low levels of fears with a noninstrumental vaginal delivery, women with high levels of fear who were delivered by unplanned cesarean section had a 12-fold increased risk of reporting a negative birth experience (OR 12.25; 95% CI 7.19–20.86). A noninstrumental vaginal delivery was associated with the most positive birth experience among the women in this study. **Conclusions:** This study shows that both levels of prenatal fear of childbirth and mode of delivery are important for birth experience. Women with low fear of childbirth who had a noninstrumental vaginal delivery reported the most positive birth experience. (BIRTH 40:4 December 2013)

**Key words:** birth experience, fear of birth, mode of delivery

A positive maternal birth experience can have long-lasting benefits by potentially strengthening self-confidence and improving bonding between mother and child (1). The birth experience can affect a woman's desire to have another child (2) and her mode of delivery preference for subsequent childbirth (3,4). In contrast, women with a negative birth experience have an overall lower fertility rate, tend to wait longer until next

pregnancy and are more likely to request a cesarean delivery (4,5). Birth experience is a multidimensional concept, and factors associated with how the birth process are perceived include antenatal fear of childbirth (3,6,7) and mode of delivery (8–10).

Between 10–20 percent of all women have negative birth experiences (11–15). Reported prevalence rates of fear of childbirth range from 5 to 40 percent, and rates

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vary by study populations, cultural perspectives, and the instrument used to estimate fear (16–21). Compared with women with low levels of fear, women with high levels of fear tend to be younger, have unplanned pregnancies, low social support, and a worse economic status (22,23).

Research has been inconclusive as to whether fear of childbirth predicts mode of delivery. A British study found no association between fear of childbirth and mode of delivery (24) whereas a Swedish study reported an increased risk of unplanned cesarean section among women with a high level of fear (25). A Norwegian study reported that women with high levels of fear were more likely to request and undergo an unplanned cesarean section (26).

There exists a lack of research about how birth experience is influenced by mode of (nonoperative and operative) delivery among women with low, intermediate or high levels of prenatal fear of childbirth. Using prospectively collected data including 3,006 nulliparous women whose first birth was during 2009–2011 in Pennsylvania, USA, we studied associations between level of fear of birth, mode of delivery, and birth experience.

### Material and Methods

The study was based on data from the First Baby Study (FBS), which included 3,006 English and Spanish speaking, nulliparous women aged 18–35 in Pennsylvania, who were enrolled in the third trimester from 2009 to 2011. The FBS is a study of the effect of mode of first childbirth on subsequent childbearing and following-up the study participants for a 3-year period postpartum. Because women who have their first child before the age of 18 or after the age of 35 are less likely to have a subsequent child within 3 years, this study excluded women younger than 18 or older than 35 at the time of the baseline interview. Participants were recruited from a variety of settings including childbirth education classes, hospital tours, health fairs, targeted mailings to potentially eligible women throughout the state of Pennsylvania, newspaper advertisements, and recruitment materials posted in low-income clinics and ultrasound centers throughout the state. Information about the study design, participant recruitment, and sample representativeness can be seen in Kjerulff et al (27). All participants carried a singleton fetus and delivered past 34 completed gestational weeks. Information was prospectively collected by telephone interviews, the first survey (the baseline interview) occurred within 10 weeks before birth and the second at 1 month postpartum. The baseline interviews occurred when women were between 30 and 42 weeks' gestation, with a median gestational age of 35 weeks.

The 1-month postpartum interviews occurred between 3 and 80 days postpartum, with a median of 32 days postpartum.

The baseline survey included a six-item scale to measure fear of upcoming birth, developed by the First Baby Study investigators and pilot-tested before deployment. The participants were investigated to what extent they felt *nervous, worried, fearful, relaxed, terrified*, and *calm* about the upcoming delivery, using *extremely, quite a bit, moderately, a little*, and *not at all* as response alternatives. A total score was created by summing participant responses to the items; the higher the score the more fearful the woman was about the upcoming delivery (the score of item "calm" was reversed). Total score could range from 6 (no fear) to 30 (extreme fear) and the overall Cronbach's Alpha for this scale (called the FBS Birth Anticipation Scale) was 0.82. We categorized the total scores into quintiles as follows: 6–13, 14–15, 16–17, 18–20, and 21–30. We then categorized the scores into three categories: 6–13 (the lowest quintile), 14–20 (the three middle quintiles), and 21–30 (the highest quintile). These categories were labeled "low fear," "intermediate fear," and "high fear." Previous research has shown that it is fair to believe that about 20 percent of all women who are pregnant have a fear of birth (11–15), so by letting only the top quintile represent the women with a real fear of birth, we hoped to avoid the inclusion of women in this group who scored high on the scale but did not actually have a fear of birth. There existed no information available on whether or not women received counseling for their potential fear, sought support or advice or explored other methods to cope with anxiety or fear related to their upcoming birth.

The primary outcome was birth experience, which was based on a 16-item scale administered in the 1 month postpartum survey, called the FBS Birth Experience Scale, which was developed by the FBS investigators and pilot-tested before use. The participants were asked to think back to right after they had their baby and report the extent to which they felt *exhausted, on cloud nine, disappointed, in pain, sick, delighted, upset, excited, worried, calm, like a failure, thankful, traumatized, sad or proud of myself*, using the response alternatives *extremely, quite a bit, moderately, a little*, and *not at all*. A summated score was created, again with some items reversed, such that the higher the score the more positive women were about their birth experience. Scores could range from 16 to 80 and the Cronbach's  $\alpha$  was 0.73. For analytic purposes, the quintile of women with the lowest score on the scale represents those having a negative birth experience.

Body mass index (BMI) was calculated using the mother's weight just before becoming pregnant, which was reported in the baseline survey and was categorized

according to the World Health Organization as: underweight or normal weight (BMI < 25), overweight (BMI 25.0–29.9), and obese (BMI ≥ 30.0). Social support was measured in the baseline survey, using five items from the MOS Social Support Survey (27). The participants were asked to tell how often each of the following kinds of support were available when needed: *someone to confide in or talk to about your problems, someone to get together with for relaxation, someone to help you with daily chores if you are sick, someone to turn to for suggestions about how to handle a personal problem, and someone to love and make you feel wanted*, using the answers *none of the time, a little of the time, some of the time, most of the time or all of the time*. The 50 percent of women with the lowest scores were considered having low support and the 50 percent with the highest scores were considered having high support. Level of poverty was calculated using a formula that takes family income (from all sources) and number of children and adults living in the household into account (28). Race, marital status, education, and whether pregnancy was intentional or not were reported in the baseline survey. Unplanned cesarean section was defined as a cesarean section performed after labor had started, either spontaneously or by induction.

The First Baby Study was approved by the Penn State College of Medicine Institutional Review Board (IRB) and the IRBs of participating hospitals located throughout the state of Pennsylvania.

### Statistical Methods

Chi-square tests were used to measure the association between maternal characteristics and fear of childbirth in three categories. Odds ratios (ORs) were estimated with 95% confidence intervals (CIs) using multiple logistic regression analyses. Odds ratios in Table 2 were adjusted for all other variables included in that table. Odds ratios in Table 3 were adjusted for social support, education, and planned pregnancy. The covariates were categorized according to Table 1. We investigated interactions between level of fear of birth (low or intermediate or high) and mode of delivery (noninstrumental vaginal or instrumental vaginal or unplanned cesarean section or planned cesarean section) and risk of negative birth experience (yes or no) in a multivariate model. The statistical software package SPSS 20.0 (SPSS Inc., Chicago, IL, USA) was used for all data analyses.

### Results

Scores on the FBS Birth Anticipation Scale ranged from a low of 6 (the minimum possible score) to a high

of 30 (the maximum possible score). The mean score was 16.9 (SD = 4.6) and the median score was 17. A larger proportion of women with high level of fear (highest score quintile) of the upcoming birth were young (18–24 years), black, had low social support, were unattached (to the father-to-be or partner), were living in poverty or near poverty, and had unplanned pregnancies (Table 1). The association between level of fear and mode of delivery was not significant ( $p = 0.710$ ). There existed no interaction between level of fear and mode of delivery ( $p = 0.971$ ).

Scores on the FBS Birth Experience Scale (FBS-BES) ranged from a low of 28 to a maximum of 80. The mean on this scale was 68.7 and the median was 70. Those in the lowest quintile (19.8% of the study population) had scores ranging from 28 to 64. Table 2 presents associations with maternal factors and risks of having a negative birth experience (the lowest score quintile). Compared with women who had a noninstrumental vaginal delivery, risks of a negative birth experience were increased among women with planned cesarean section (OR = 1.62), vaginal instrumental delivery (OR = 2.19), and unplanned cesarean section (OR = 3.14). Compared with women reporting low fear of childbirth before delivery, women with high fear, and women with intermediate fear had an almost fivefold and an almost threefold increased risk of a negative birth experience, respectively. Low social support, having a college degree or higher education, and having an unplanned pregnancy were other factors independently associated with increased risks of having a negative birth experience. Compared with normal weight women, obese women had a reduced risk of a negative birth experience (Table 2).

In Fig. 1, we present crude rates of a negative birth experience by mode of delivery and antenatal fear of childbirth. In women with high fear, rates of a negative birth experience increased from 24 percent among women with a noninstrumental vaginal delivery to 44 percent among women with unplanned cesarean section. A slightly larger rate difference in negative birth experience was observed among women with intermediate fear: from 14 percent among women with a noninstrumental vaginal delivery to 36 percent among women delivered by unplanned cesarean section, thus an increase in a negative birth experience by 22 percent. Among women with low level of fear, corresponding rates were 6 and 15 percent, and the rate difference was only 9 percent.

In Table 3, we present risks of negative birth experience by combinations of antepartal fear of childbirth and mode of delivery, using women with no fear of upcoming birth having a noninstrumental vaginal delivery as the reference category. In each strata of level of fear, the risk of having a negative birth experience increased

gradually with planned cesarean section, vaginal instrumental delivery and unplanned cesarean section. In each strata of mode of delivery, the risk of having a negative birth experience increased with level of fear of childbirth before delivery. Compared with the women with low

level of fear having a noninstrumental vaginal delivery, women with high level of fear had at least a 12-fold risk of having a negative birth experience if delivered by unplanned cesarean section and a 10-fold increase in risk if having an instrumental vaginal delivery.

**Table 1. Maternal characteristics by level of fear**

Characteristic	Level of fear*			p
	Low n = 692 No. (%)	Intermediate n = 1,702 No. (%)	High n = 611 No. (%)	
Mode of delivery				
Noninstrumental vaginal delivery	443 (64.0)	1060 (62.3)	378 (61.9)	0.378
Planned cesarean section	27 (3.9)	92 (5.4)	36 (5.9)	
Instrumental vaginal delivery	66 (9.5)	136 (8.0)	59 (9.7)	
Unplanned cesarean section	156 (22.5)	414 (24.3)	138 (22.6)	
Age				
18–24	199 (28.8)	407 (23.9)	205 (33.6)	< 0.001
25–29	266 (38.4)	716 (42.1)	210 (34.4)	
30–36	227 (32.8)	579 (34.0)	196 (32.1)	
Prepregnancy BMI kg/m <sup>2</sup>				
< 25.0	409 (59.7)	960 (57.0)	340 (56.4)	0.725
25–29.9	142 (20.7)	380 (22.6)	134 (22.2)	
≥ 30	134 (19.6)	343 (20.4)	129 (21.4)	
Race/Ethnicity				
White	565 (81.6)	1455 (85.5)	481 (78.7)	0.001
Black	51 (7.4)	102 (6.0)	68 (11.1)	
Hispanic	48 (6.9)	82 (4.8)	36 (5.9)	
Other	28 (4.0)	62 (3.6)	26 (4.3)	
Social support				
Low	270 (39.0)	844 (49.6)	314 (51.5)	< 0.001
High	422 (61.0)	858 (50.4)	296 (48.5)	
Marital status				
Married	491 (71.0)	1,259 (74.0)	366 (60.0)	< 0.001
Living with partner	120 (17.3)	278 (16.3)	146 (23.9)	
Not living with partner	42 (6.1)	97 (5.7)	48 (7.9)	
Unattached	39 (5.6)	68 (4.0)	50 (8.2)	
Education				
High school degree or less	112 (16.2)	250 (14.7)	139 (22.7)	< 0.001
Some technical college	198 (28.6)	437 (25.7)	168 (27.5)	
College graduate or higher	382 (55.2)	1,015 (59.6)	304 (49.8)	
Poverty				
Poverty	61 (9.4)	129 (8.0)	56 (10.0)	< 0.001
Near poverty	45 (6.9)	124 (7.7)	78 (13.9)	
Not poverty	545 (83.7)	1,359 (84.3)	428 (76.2)	
Pregnancy was planned				
Yes	455 (65.8)	1,136 (66.7)	308 (50.4)	< 0.001
No	236 (34.1)	560 (32.9)	301 (49.3)	

\*Low = lowest quintile; intermediate = 2nd to 4th quintiles; high = highest quintile.

**Table 2. Rates and adjusted odds ratios for a negative birth experience**

Variable	Total No. (n = 3,005)	Rate No. (%)	Negative birth experience*	
			Adjusted <sup>†</sup>	
			OR	95% CI
Mode of delivery				
Noninstrumental vaginal delivery	1882	262 (13.9)	Ref	
Planned cesarean section	261	68 (26.1)	1.62	1.04–2.53
Instrumental vaginal delivery	155	30 (19.4)	2.19	1.57–3.06
Unplanned cesarean section	708	229 (32.3)	3.14	2.50–3.95
Fear of childbirth				
Low	692	57 (8.2)	Ref	
Intermediate	1702	348 (20.4)	2.85	2.08–3.92
High	611	184 (30.1)	4.88	3.44–6.92
Age (years)				
18–24	811	126 (15.5)	Ref	
25–29	1,193	241 (20.2)	0.94	0.67–1.32
30–36	1,002	222 (22.2)	0.95	0.66–1.38
Prepregnancy BMI				
< 25.0	1,709	351 (20.5)	Ref	
25–29.9	656	130 (19.8)	0.88	0.69–1.13
≥ 30	607	102 (16.8)	0.66	0.50–0.87
Race/Ethnicity				
White	2,502	491 (19.6)	Ref	
Black	221	43 (19.5)	1.14	0.71–1.84
Hispanic	166	21 (12.7)	0.60	0.34–1.06
Other	116	33 (28.4)	1.34	0.84–2.15
Social support				
Low	1,428	365 (25.6)	1.75	1.43–2.15
High	1,577	224 (14.2)	Ref	
Marital status				
Married	2,117	438 (20.7)	Ref	
Living with partner	544	102 (18.8)	0.94	0.68–1.31
Not living with partner	187	19 (10.2)	0.42	0.22–0.81
Unattached	157	30 (19.1)	1.04	0.60–1.80
Education				
High school degree or less	501	73 (14.6)	Ref	
Some technical college	804	130 (16.2)	1.24	0.84–1.82
College graduate or higher	1,701	386 (22.7)	1.83	1.21–2.76
Poverty				
Poverty	246	41 (16.7)	1.06	0.69–1.63

(continued)

Table 2 Continued

Variable	Total No. (n = 3,005)	Rate No. (%)	Negative birth experience*	
			Adjusted <sup>†</sup>	
			OR	95% CI
Near poverty	248	51 (20.6)	1.27	0.86–1.87
Not poverty	2,332	467 (20.0)	Ref	
Planned pregnancy				
Yes	1,899	358 (18.9)	Ref	
No	1,098	226 (20.6)	1.38	1.16–1.63

\*Includes the quintile (20%) of women with the most negative birth experience; <sup>†</sup>Adjusted for all other variables in table.

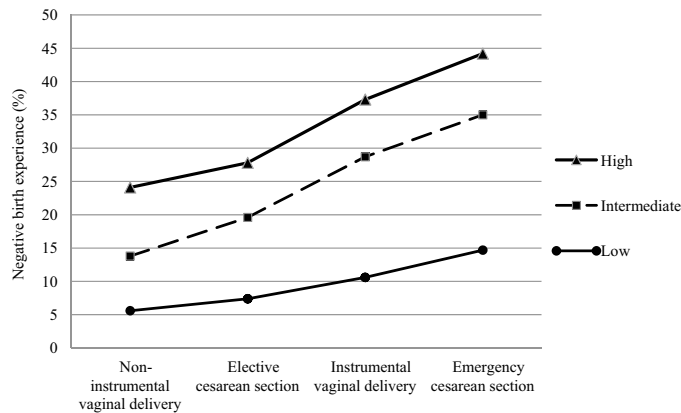


Fig. 1. Unadjusted rates of a negative birth experience (highest quintile) by level of fear of labor and mode of delivery.

Table 3. Maternal fear of birth and mode of delivery and risk of having a negative birth experience<sup>a</sup>

Mode of delivery	Fear of childbirth								
	Low			Intermediate			High		
	No. <sup>b</sup>	OR <sup>c</sup>	(95% CI)	No. <sup>b</sup>	OR <sup>c</sup>	(95% CI)	No. <sup>b</sup>	OR <sup>c</sup>	(95% CI)
Noninstrumental vaginal delivery	443	1.00 <sup>d</sup>		1060	2.52	1.62–3.92	378	5.13	3.20–8.23
Planned cesarean section	27	1.30	0.29–5.83	92	3.80	1.96–7.36	36	5.99	2.57–13.95
Instrumental vaginal delivery	66	1.96	0.81–4.76	136	6.11	3.50–10.65	59	10.35	5.25–20.39
Unplanned cesarean section	156	2.99	1.63–5.46	414	8.48	5.38–13.37	138	12.25	7.19–20.86

<sup>a</sup>Includes the quintile (20%) of women with the most negative birth experience; <sup>b</sup>denotes number of women included in the analyses; <sup>c</sup>denotes odds ratios, which are adjusted for social support, education, and planned pregnancy; <sup>d</sup>the women in this group served as the reference group.

Discussion

We found that rates and risks of a negative birth experience were influenced both by level of antenatal fear of childbirth and mode of delivery. Women with low levels of fear with noninstrumental vaginal delivery

experienced the lowest risk of a negative birth experience, and women with high levels of fear delivered by unplanned cesarean section or instrumental vaginal delivery were to a higher extent represented in the quintile of women with the most negative birth experience.



This study is unique because it shows the interplay between the different combinations of level of fear and mode of delivery and birth experience. For example, we were able to show that, compared with women with intermediate and high levels of fear, women with low levels of fear rarely have a negative birth experience, disregarding mode of delivery. In congruence with previous research (22,23), women with low levels of fear were characterized by having high levels of social support, they were well educated, were more often married, older, and had planned pregnancies. As previously reported in another study (29), a higher education was not only associated with both lower levels of fear, but also an increased risk of a negative birth experience. We speculate that these findings may be explained by differences in expectations of the upcoming birth. Women with higher education were also generally older, and an age-related increased risk of a more complicated delivery may lead to a more negative birth experience (29). The youngest women were more exposed to social and psychological problems, which may have affected their expectations and experiences during labor. A previous study reported that women with low levels of fear of childbirth are generally less anxiety-prone, less irritable and have lower levels of somatic anxiety (30). Specific personality traits among these women such as high emotional stability and being extraverted can be associated with less risk of complications during childbirth and a more positive birth experience (31). Interestingly, the theory about the importance of preoperative fear or anxiety as a factor in postoperative emotional responses and recovery was proposed by Irving Janis in 1958 (32).

We were also able to show that birth experience among women with intermediate or high levels of fear were to a greater extent affected by an instrumental vaginal delivery or unplanned cesarean section. Problematically, it has been shown that women with high levels of fear are more likely to use epidural analgesia, which in turn is associated with increased levels of intervention and cesarean section (33). Women with high levels of fear of birth have been given much attention in previous research (34–36) and should be continued to be given much focus as result of the high risk of a negative birth experience. As it seems in our study, a non-instrumental vaginal delivery is the mode of delivery which is least likely to contribute to a negative experience among all women.

A noninstrumental vaginal delivery can never be guaranteed, and women undergoing a planned cesarean section were nearly as satisfied as those having a noninstrumental vaginal delivery. A planned cesarean section for women with high fears could then seem like a good alternative. However, whether or not a planned cesarean section should be carried out on maternal request is a controversial issue (37,38). In a study with

the aim to investigate maternal satisfaction following vaginal delivery after cesarean section and cesarean section after previous vaginal delivery, maternal satisfaction with vaginal delivery was high. Those that had experienced both modes of delivery reported they would prefer vaginal births in future pregnancies (39).

In this study we used several newly developed instruments, the FBS Birth Anticipation Scale and the FBS Childbirth Experience Scale, to define levels of *fear of birth* and *birth experience*. Although these are newly developed instruments, they exhibited good levels of internal consistency reliability, and evidence of validity by means of the associations with the other variables in this study. We categorized women into three levels of fear (low, intermediate and high), using the lowest and highest quintiles to identify those with low and high levels of fear of childbirth. In addition, we defined women in the lowest quintile on the birth experience scale as having a negative birth experience, relative to the other women in the study. Converting continuous scales into categories using quintiles is a common strategy in social science and epidemiologic research and provided us with a way of measuring and visualizing the associations between fear of childbirth, mode of delivery, and childbirth experience in a unique way. However, categories based on quintiles are based on the distribution of scores in the study population and the cutoff values would likely be different in other populations—limiting the external validity of this study.

In spite of the limitations in this study, our results clearly demonstrate that both antenatal fear of birth and mode of delivery have a significant impact on women's birth experience. For the past 25 years, women with antenatal fear in Sweden have been receiving counseling to lower their fear and prepare for the upcoming birth. However, even though a lot of women report the counseling to be helpful (40), the evidence in favor of such treatment is not overwhelming (36,40). There exists far more evidence to show the benefits of one-to-one care and continuous support in labor. In a systematic review by Hodnett et al, it was concluded that women who received continuous labor support were more likely to have a positive birth experience, they were less likely to use pain medications, were more likely to give birth non-instrumentally and had slightly shorter labors (41). It was stated that all women should have continuous support during labor.

It can be concluded that women's antenatal feelings of the upcoming birth are of high importance, just as the actual birthing process itself. As women's experiences of birth is a complex but important issue, health care practitioners should have a holistic view of the birth and inquire about the psychological well-being when evaluating care and not only the medical outcomes.

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IV



# Mode of delivery and the probability of subsequent childbearing: a population-based register study

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**Objective** To investigate the relationship between mode of first delivery and probability of subsequent childbearing.

**Design** Population-based study.

**Setting** Nationwide study in Sweden.

**Population** A cohort of 771 690 women who delivered their first singleton infant in Sweden between 1992 and 2010.

**Methods** Using Cox's proportional-hazards regression models, risks of subsequent childbearing were compared across four modes of delivery. Hazard ratios (HRs) were calculated, using 95% confidence intervals (95% CIs).

**Main outcome measures** Probability of having a second and third child; interpregnancy interval.

**Results** Compared with women who had a spontaneous vaginal first delivery, women who delivered by vacuum extraction were less likely to have a second pregnancy (HR 0.96, 95% CI 0.95–0.97), and the probabilities of a second childbirth were substantially lower among women with a previous emergency

caesarean section (HR 0.85, 95% CI 0.84–0.86) or an elective caesarean section (HR 0.82, 95% CI 0.80–0.83). There were no clinically important differences in the median time between first and second pregnancy by mode of first delivery. Compared with women younger than 30 years of age, older women were more negatively affected by a vacuum extraction with respect to the probability of having a second child. A primary vacuum extraction decreased the probability of having a third child by 4%, but having two consecutive vacuum extraction deliveries did not further alter the probability.

**Conclusions** A first delivery by vacuum extraction does not reduce the probability of subsequent childbearing to the same extent as a first delivery by emergency or elective caesarean section.

**Keywords** Elective caesarean section, emergency caesarean section, mode of delivery, subsequent childbearing, vacuum extraction.

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## Introduction

In Sweden, the prevalence of deliveries by vacuum extraction has increased from 10% in 1990 to 14% in 2012.<sup>1</sup> In 2012, every seventh nulliparous woman was delivered by vacuum extraction, yet little is known about subsequent childbearing among these women.

Compared with spontaneous vaginal deliveries, some international studies have reported lower birth rates after a delivery by vacuum extraction,<sup>2,3</sup> whereas other studies have reported no differences.<sup>4–7</sup> Results investigating whether a vacuum extraction in the first delivery influences the interpregnancy interval (IPI) are also conflicting.<sup>4,8,9</sup>

Limitations in previous studies include hospital-based rather than population-based study populations, long time since conducting the study (and therefore potential changes in obstetric practice),<sup>2,4</sup> small study samples,<sup>3,5,10</sup> and lack of control for potentially important confounding factors.<sup>7</sup> The largest study was performed in Pennsylvania, USA, where the use of vacuum extraction has been declining over the last decades.<sup>7</sup> The rate of vacuum extraction in the USA also varies between regions and hospitals,<sup>11,12</sup> and is as low as 0.02% in some hospitals,<sup>13</sup> which makes generalization questionable. Studies conducted on subsequent childbearing report that women with a primary caesarean section are less likely to have

one or more subsequent births than women who deliver vaginally.<sup>7,8,14</sup>

The use of vacuum extraction in Sweden differs from the use of vacuum extraction in the USA and possibly also other countries. In Sweden, vacuum extraction is the primary choice when an expedited delivery is indicated and the selection criteria are met (i.e. fully dilated cervix, fetal membranes are broken, fetal head at or below the ischial spines, and gestational age >34 weeks). All doctors receive training in this procedure. In the USA, the numbers of healthcare providers who are adequately trained to perform vacuum deliveries is decreasing, and therefore prefer to deliver by caesarean section.<sup>15</sup> There is a concern that there is an overuse of caesarean section and that primary caesarean section could be prevented by the increased use of instrumental delivery.<sup>16</sup> It is of importance to study subsequent childbearing in relation to mode of delivery, as it is an essential factor when balancing the short-term and long-term trade-offs between caesarean and vaginal delivery.

Using the Swedish Medical Birth Register, we were able to study mode of delivery and the probability of subsequent childbearing on a population-based level, and also to control for a number of potential confounding factors. Our aims were to investigate: (1) whether the probability of having a subsequent birth differs between women with a primary vacuum extraction, or with an emergency or elective caesarean section, and women with a primary spontaneous vaginal delivery; (2) whether the IPI between the first and the second pregnancy differs by mode of first delivery; and (3) whether mode of the first and the second delivery is associated with the probability of having a third child.

## Methods

### Study population

The study was based on data from the Swedish Medical Birth Register, which includes more than 98% of all births in Sweden.<sup>17</sup> Starting from the first antenatal visit information is prospectively collected during pregnancy and delivery, using standardised records. Using the unique national registration number assigned to all Swedish residents,<sup>18</sup> the first live birth record was linked with subsequent deliveries for the same woman until the end of the study period. A cohort of 805 820 women who had their first delivery between 1992 and 2010 was followed until 31 December 2010. We excluded women with multiple births ( $n = 13\ 055$ ) and stillbirths ( $n = 4390$ ). We also excluded women with missing or incomplete information on the national registration number, which made the linkage of successive births impossible ( $n = 1647$ ), and women with missing information on mode of delivery ( $n = 7909$ ).

Lastly, women who gave birth by forceps were excluded because of infrequent use ( $n = 1712$ ; <1%). Thus, data from 771 690 women were used in the analyses.

In Sweden, women attend their first antenatal visit at 8–12 weeks of gestation.<sup>19</sup> Height, weight, and smoking status are then recorded. Throughout the course of pregnancy, blood pressure, proteinuria, and glucosuria are checked repeatedly. By using capillary glucose (measured between four and six times during pregnancy, starting at the first antenatal visit), all women are screened for gestational diabetes. Data on maternal age and parity were collected at delivery. Using the unique national registration numbers, the Swedish Medical Birth Register was linked with the nationwide Swedish Population and Education registers to obtain individual information about the mother's country of birth and level of education, respectively.

Information about maternal diseases or pregnancy complications was classified according to the Swedish version of the ninth and tenth revisions of the International Classification of Diseases, (ICD-9 and ICD-10, respectively). Information on maternal disorders included pregestational diabetes (insulin-dependent or noninsulin-dependent; ICD-9 codes 250 and 648A; ICD-10 codes E10–E14 and O240–O243), gestational diabetes (ICD-9 code 648W; ICD-10 code O244), pregestational hypertension (self-reported by a check box at the first antenatal visit; or by ICD-9 codes 401–405, 642C, and 642H; or by ICD-10 codes I10–I15, O10, and O11), and pre-eclampsia (including eclampsia; ICD-9 codes 642E–642G; ICD-10 codes O14 and O15). Infertility problems included fertility problems with and without surgical or hormonal treatment, assisted pregnancy, or other stated but unspecified infertility problems. Information on this variable is documented by the midwife in the antenatal records at the first antenatal visit.

Gestational age was determined using the following hierarchy: early second trimester ultrasound; date of last menstrual period, reported at the first antenatal visit; and from a postnatal assessment.

Vacuum extraction, emergency caesarean section, or elective caesarean section were the dependent variables. Information about these variables was recorded during labour in the obstetric records. Emergency caesarean section was defined as a caesarean section performed after the delivery had started, either spontaneously or by induction of labour.

### Outcome variables

Outcome variables were probability of giving birth to a second child, probability of giving birth to a third child, and IPI. Interpregnancy interval was defined as the number of months (i.e. 30-day periods) from the first delivery until

the estimated date of onset of the second pregnancy (by subtracting the gestational length from the date of the second delivery).

### Statistical analysis

Rates of women giving birth to a second and third child (in percentages) were calculated as a function by mode of first delivery (spontaneous vaginal delivery, vacuum extraction, emergency caesarean section, and elective caesarean section). The association between a women's mode of delivery and subsequent reproduction was studied by using Cox's proportional-hazards models, taking both a possible subsequent delivery and the time interval to the next delivery into account. Differences in IPI in relation to mode of delivery were calculated using linear regression. The time variable was time between a delivery and a possible subsequent delivery. Women were included in the study regardless of having a subsequent delivery or not. Women who did not have subsequent delivery during the observation period were censored at an age of 45 years. All results are reported as hazard ratios (HRs) with 95% confidence intervals (95% CIs).

Predictors included mode of delivery in the first and second deliveries and potential confounding factors (maternal

age, maternal height, body mass index, maternal morbidity, birthweight, and infertility). Characteristics and potential confounders of women by mode of first delivery are presented in Table 1. In the multivariate logistic regression analyses (presented in Table 2), maternal age was included as a categorical variable with the following categories: <20, 20–24, 25–29, 30–34, 35–39, or ≥40 years. Maternal height was included as ≤154, 155–174, and ≥175 cm. Body mass index (BMI) was calculated from the information on height and weight recorded at the first antenatal visit, and was categorised according to the World Health Organization as: underweight (BMI <18.5 kg/m<sup>2</sup>), normal weight (BMI 18.5–24.9 kg/m<sup>2</sup>), overweight (BMI 25.0–29.9 kg/m<sup>2</sup>), mild obesity (BMI 30.0–34.9 kg/m<sup>2</sup>), and severe obesity (BMI ≥35.0 kg/m<sup>2</sup>).<sup>20</sup> In the final analyses, BMI was controlled for as a linear variable, as adjustments for the categories above did not improve the analysis. Birthweight was included as a categorical variable with the following categories: <2500, 2500–2999, 3000–3499, 3500–3999, 4000–4499, and ≥4500 g. In model 1 the HR of having a second child-birth was adjusted for time, in model 2 it was adjusted for time and maternal age, and in model 3 adjustments were made for time, maternal age, BMI, height, maternal morbidity (pre-eclampsia, diabetes, and chronic hypertension),

**Table 1.** Characteristics of women by mode of first delivery

	Spontaneous vaginal delivery (n = 549 174)	Vacuum extraction (n = 104 679)	Emergency cesarean section (n = 81 435)	Elective cesarean section (n = 44 111)
Age (years)	27.1 ± 4.8	28.6 ± 4.9	29.3 ± 5.1	29.8 ± 5.5
BMI (kg/m <sup>2</sup> )	23.6 ± 3.9	23.8 ± 4.0	25.1 ± 4.7	24.4 ± 4.6
Height (cm)	166.9 ± 6.2	166.1 ± 6.3	164.7 ± 6.5	166.0 ± 6.7
Morbidity*	4.1%	5.4%	10.3%	18.2%
Infertility problems**	7.6%	9.3%	11.2%	13.0%

Values are given as means ± standard deviations or as rates (in %).

\*Any of the following diagnoses: pre-eclampsia; diabetes; chronic hypertension.

\*\*Fertility problems, with and without treatment, including assisted pregnancy, hormonal treatment, and surgical and other treatments.

**Table 2.** Mode of first delivery and hazard ratio of having a second birth

Mode of delivery	%	n	Model 1 HR 95% CI	Model 2 HR 95% CI	Model 3 HR 95% CI
Spontaneous vaginal delivery	70.5	549 174	Ref	Ref	Ref
Vacuum extraction	13.4	104 679	0.94 (0.93–0.95)	0.97 (0.96–0.98)	0.96 (0.95–0.97)
Emergency cesarean section	10.4	81 435	0.79 (0.78–0.80)	0.83 (0.82–0.84)	0.85 (0.84–0.86)
Elective cesarean section	5.7	44 111	0.72 (0.71–0.73)	0.78 (0.77–0.79)	0.82 (0.80–0.83)

Model 1. Adjusted for time.

Model 2. Adjusted for time and maternal age.

Model 3. Adjusted for time, maternal age, BMI, height, maternal morbidity, infertility and birthweight.

and infertility. These variables have all been previously shown to affect the intentions and ability to have more than one child, as well as mode of delivery.<sup>2,3,5,9</sup>

In order to show interactions between age and probability to have a second child in relation to primary mode of delivery, Kaplan–Meier survival curves were produced. Three age categories (<25, 25–34, and ≥35 years) were used and women with morbidity, obesity (BMI ≥ 30), short stature (≤154 cm), or infertility problems were excluded.

Maternal country of birth, level of education, and smoking did not have confounding effects, and were therefore not included in the final analyses. To allow the effect of mode of delivery to vary across maternal age strata, an interaction term between maternal age and mode of delivery were included. Also, an interaction term between mode of delivery at first and second birth was included in the analysis of propensity for a third child.

The statistical software package StataIC 12 was used for all data analyses. The study was approved by the Research Ethics Committee at Karolinska Institutet, Stockholm.

## Results

Of 771 690 women who delivered their first singleton live-born infant during the period 1990–2010, 495 329 (64.2%) women had a second delivery and 118 243 (15.3%) women also had a third delivery during the same study period. During 1990–2010, the rate of emergency caesarean section among primiparous women increased from 6.9 to 11.8%, the elective caesarean section rate increased from 3.6 to 6.4%, and vacuum extraction rate increased from 11.0 to 13.1%.

Women who had an instrumental first delivery (emergency caesarean section, elective caesarean section, or vacuum extraction) tended to be older, shorter, and/or heavier than women with a primary spontaneous vaginal delivery ( $P < 0.001$  for each comparison, Table 1). Compared with women with a primary spontaneous vaginal delivery, women with an instrumental first delivery had higher rates of morbidity and infertility problems ( $P < 0.001$  for each comparison). These rates were generally higher for women with a primary (elective or emergency) caesarean section than for women with a primary vacuum extraction.

We found that mode of first delivery influenced the probability of having a second delivery. Of women with a primary spontaneous vaginal delivery, 80.4% had a second childbirth within 5 years, whereas the corresponding rate for women with a primary vacuum extraction was 76.8%, and rates for women with emergency and elective caesarean sections were 70.3 and 65.7%, respectively. Cox regression analyses showed that even after adjustment for variations in time and maternal age, there were statistically significant differences between the different modes of delivery and

probability of having a second delivery (Table 2, model 2). Compared with women with a primary spontaneous vaginal delivery, women with a vacuum extraction had a slightly lower probability of having a second delivery (HR 0.97, 95% CI 0.96–0.98; Table 2, model 2), and even lower probabilities of a second delivery were obtained for women delivered by emergency caesarean section (HR 0.83, 95% CI 0.82–0.84) or by elective caesarean section (HR 0.78, 95% CI 0.77–0.79). Further adjustments for BMI, height, maternal morbidity infertility or birthweight did not substantially influence the probability of a second delivery as a function of an instrumental first delivery (Table 2, model 3).

Maternal age was negatively and linearly correlated with IPI between first and second pregnancies. Women younger than 25 years of age at first delivery had a median IPI of 34 months, whereas women aged 35 years and older had a median IPI of just 27 months. There was an interaction effect between maternal age and vacuum extraction at first delivery and the probability of a second childbirth ( $P < 0.001$ ). Compared with women who were younger than 25 years of age, women aged 35 years or older were less likely to have a second childbirth during follow-up (Figure 1).

There were minor differences in median IPI between first and second pregnancy in relation to mode of delivery ( $P < 0.001$ ). Compared with women who had a primary spontaneous vaginal delivery, the IPI was only 8 days longer for women with a primary vacuum extraction, and 43 days longer for women with a primary elective caesarean section or an emergency caesarean section.

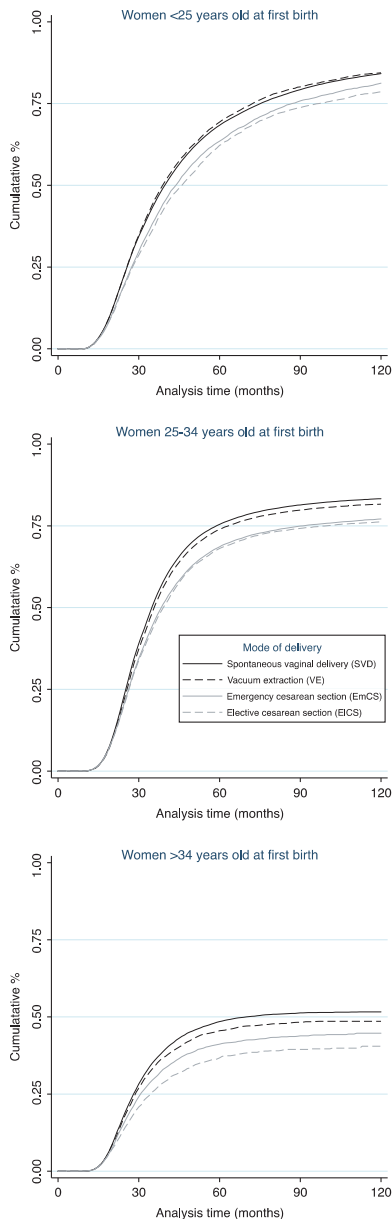
Among women who had two subsequent deliveries, we compared the probability of a third delivery by mode of first and second delivery (Table 3). Women with first and second spontaneous vaginal deliveries were included in the reference group. Irrespective of the mode of first delivery, a second (elective or emergency) caesarean delivery reduced the probability of a third childbirth. In contrast, a second vacuum extraction delivery was not associated with reduced probabilities of a third childbirth. In fact, among women with an elective caesarean section at first delivery, a vacuum extraction at second delivery was associated with an increased probability of a third childbirth.

## Discussion

### Main findings

We found that women delivered by vacuum extraction in their first pregnancy had a 4% lower probability of having a second childbirth, compared with women with a primary spontaneous vaginal delivery; however, compared with women who had a first delivery by emergency caesarean section or elective caesarean section, women with a primary





**Figure 1.** Cumulative percentage of women who had at least one subsequent birth. Time (in months) between the first birth and the second pregnancy (leading to a birth). Women with morbidity, obesity ( $\text{BMI} \geq 30 \text{ kg/m}^2$ ), short stature ( $\leq 154 \text{ cm}$ ), infertility problems, or birthweight  $<2500 \text{ g}$  or  $>4500 \text{ g}$  at first birth are excluded.

vacuum extraction had a higher probability of having a second childbirth. Similar reduced probabilities of having a third childbirth were obtained among women who had an elective caesarean section or an emergency caesarean section for their second delivery, whereas a second vacuum extraction delivery did not reduce the probability of a third childbirth. Mode of delivery had a negligible influence on length of interpregnancy intervals.

### Strengths and limitations

The major strength of this study is the large sample size based on nationwide registers. As mode of delivery is potentially associated with level of insurance, and with patient's and doctor's preferences, it is beneficial to perform a study like this in Sweden where antenatal and obstetrical care is free of charge, and where all obstetricians receive adequate training in performing a vacuum extraction. When an expedited delivery is needed and patient criteria are met, a vacuum extraction is considered the primary choice of method of delivery in Sweden, rather than an emergency caesarean section. These factors can reduce the risk of selection bias. As a result of the extensive registers we were able to adjust for confounding factors known to influence both mode of delivery and subsequent fertility.

Limitations include that we did not have any information on miscarriages, childbearing plans, or length of labour among the women, which potentially could have influenced the results. Also, it is an observational study, and even though we can report on a low but significant association between a primary vacuum extraction and a decreased probability of having a second child, we cannot draw conclusions about causation.

### Interpretation

There are at least three possible explanations why women with a primary vacuum extraction have fewer subsequent childbirths than women with a primary spontaneous vaginal delivery. Women with operative deliveries (especially caesarean sections, but possibly also vacuum extraction) constitute a group of women with predisposing infertility problems or may undergo biological changes as a result of the operation, leading to fewer consecutive children.<sup>21</sup> The second and more plausible explanation is that prolonging or abstaining from a second pregnancy after a primary delivery by vacuum extraction may be a voluntary choice. A primary vacuum extraction has previously been associated with a traumatic birth experience, which in turn has been associated with fewer subsequent deliveries.<sup>22–24</sup> Thus, a woman with a primary traumatic operative delivery may change her childbearing plans.<sup>22,23</sup> Third, women with a primary instrumental delivery may also be a selected group; these women may be less likely to have a second child even before the first delivery. In a study by Kjerulff et al.,<sup>9</sup> only 85% of the women

**Table 3.** Relative risk of having a third child by mode of delivery in first and second birth, compared with two consecutive spontaneous vaginal deliveries

Mode of delivery 1st birth	Mode of delivery 2nd birth							
	Spontaneous vaginal delivery		Vacuum extraction		Emergency cesarean section		Elective cesarean section	
	%	HR* (95% CI)	%	HR* (95% CI)	%	HR* (95% CI)	%	HR* (95% CI)
Spontaneous vaginal delivery (n = 367 950)	93.7	Ref	1.4	0.94 (0.88–1.00)	2.0	0.92 (0.87–0.97)	2.9	0.88 (0.84–0.92)
Vacuum extraction (n = 61 823)	82.7	0.97 (0.95–0.99)	6.1	0.96 (0.89–1.04)	3.9	0.84 (0.76–0.93)	7.4	0.78 (0.72–0.85)
Emergency cesarean section (n = 43 988)	36.0	1.02 (0.99–1.06)	9.6	1.01 (0.94–1.09)	21.7	0.82 (0.78–0.87)	32.7	0.75 (0.71–0.78)
Elective cesarean section (n = 22 494)	43.5	1.01 (0.96–1.06)	8.0	1.12 (1.01–1.25)	12.8	0.90 (0.82–0.99)	35.7	0.77 (0.72–0.82)

\*Adjusted for maternal age, maternal height, BMI, morbidity, infertility and birthweight.

who underwent a primary delivery by vacuum extraction had a pre-delivery intention of having one or more children after the first one, compared with 91% among those with a spontaneous vaginal delivery or 90% among women with emergency caesarean section or elective caesarean section. In this study we have no information on the pre-delivery intentions of having a second child, and neither do we have information on birth experience that could explain the reduced rate of secondary deliveries.

Hill's criteria for causation partly support the hypothesis that the lower rate of subsequent births among women with a primary vacuum extraction, in comparison with women who had a primary spontaneous vaginal delivery, may be causal.<sup>25</sup> The effect occurs after the cause, and the greater the exposure to operative delivery (here, emergency caesarean section is considered worse) the greater the incidence of the effect. There is a plausible mechanism between cause and effect. Although the association is highly significant, a previous vacuum extraction was only associated with a 4% reduced probability of subsequent childbearing. In addition, this is an observational study and our results should therefore be interpreted cautiously.

Compared with women with a primary spontaneous vaginal delivery, IPI in women with a primary vacuum extraction was only 8 days longer. This is an interesting finding as one could speculate that if the first delivery was prolonged and/or experienced as traumatic, the woman would need some extra time to recover before getting pregnant again. As the IPI was similar between women with a primary spontaneous vaginal delivery and women with a primary vacuum extraction, there is no evidence for women becoming subfertile after a vacuum extraction. We therefore find it likely that the 4% reduction of a second childbirth after a primary vacuum extraction is mainly voluntary.

A positive and novel finding in this study is that a second subsequent delivery by vacuum extraction does not affect the probability of having a third child, compared

with women who had a primary vacuum extraction followed by a spontaneous vaginal delivery. One could speculate that if vacuum extraction was considered traumatic by many women, a second vacuum extraction would have a dose-response effect, and would frighten women even more; however, irrespective of primary mode of delivery, a vacuum extraction in the second delivery did not negatively impact on the probability of having a third child. This is in sharp contrast with an elective caesarean section or an emergency caesarean section in the second delivery, which reduced the probability of a third childbirth, irrespective of mode of first delivery. Some women who have had two consecutive caesarean sections might be counselled to avoid subsequent pregnancies, however, because of the risk of abnormal placentation as well as the risk attendant to further operative delivery.

## Conclusion

This study shows very small differences in subsequent childbearing between women who deliver by spontaneous vaginal delivery versus vacuum extraction. In addition, vacuum extraction provides a safe and appropriate opportunity to prevent the overuse of primary caesarean section. Except for Sweden, there has been a decreasing use of vacuum extraction in many regions in high-income countries, whereas the rate of caesarean sections has increased.<sup>11,12</sup> Compared with a primary vaginal delivery, a primary caesarean section is associated with some increases in morbidity and mortality, but the downstream effects are even greater because of the risks from repeat caesarean section in future pregnancies,<sup>26</sup> and the consequences on subsequent childbearing.<sup>7,8,14</sup> Lack of training among doctors and an awareness of the increased risks of cerebral haemorrhage and anal sphincter rupture are probably contributing factors to the decreased use of vacuum extraction in some countries and regions. The absolute risk of traumatic cere-

bral haemorrhage during a vacuum extraction delivery is still extremely low (0.8/10 000),<sup>27</sup> however, and approximately 2% of all women delivered by vacuum extraction will receive an anal sphincter rupture, with incontinence problems lasting longer than 6 months.<sup>28,29</sup>

Based on the results from this and other studies on short- and long-term outcomes after a vacuum extraction, we feel reassured that vacuum extraction delivery has a clear role in obstetrical practice, and that obstetricians should be adequately trained to use vacuum extraction in order to reduce the number of primary caesarean sections. Based on the current evidence it is neither ethically nor economically justified to perform an emergency caesarean section when the patient is an appropriate candidate for vacuum extraction delivery.

### Disclosure of interests

All authors declare that they have no conflicts of interest.

### Contribution to authorship

CE, JD, SC, and GA wrote the article. CE and JD conceived the original idea and JD performed the data analyses with mentorship from GA. SC contributed significantly to the interpretation of the results. All authors have approved the final version of the article.

### Details of ethics approval

This study was approved by the Karolinska Institute Ethical Review Board (5 December 2013, reference numbers 2011/195-21/2 and 2013/2155-32).

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